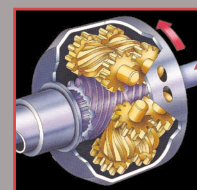
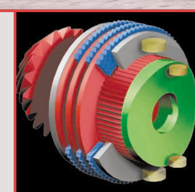
quattro

The Evolution of Audi All-Wheel Drive

Audi Academy





Audi Academy

Self-Study Program
Course Number 962103

Audi of America, Inc.
Service Training
Printed in U.S.A.
Printed in 6/2001
Course Number 962103

Always check Technical Bulletins and the Audi Worldwide Repair Information System for any information that may supersede any information included in this booklet.

Over 20 years ago, Audi brought all-wheel drive to the sports car market with the Audi quattro.

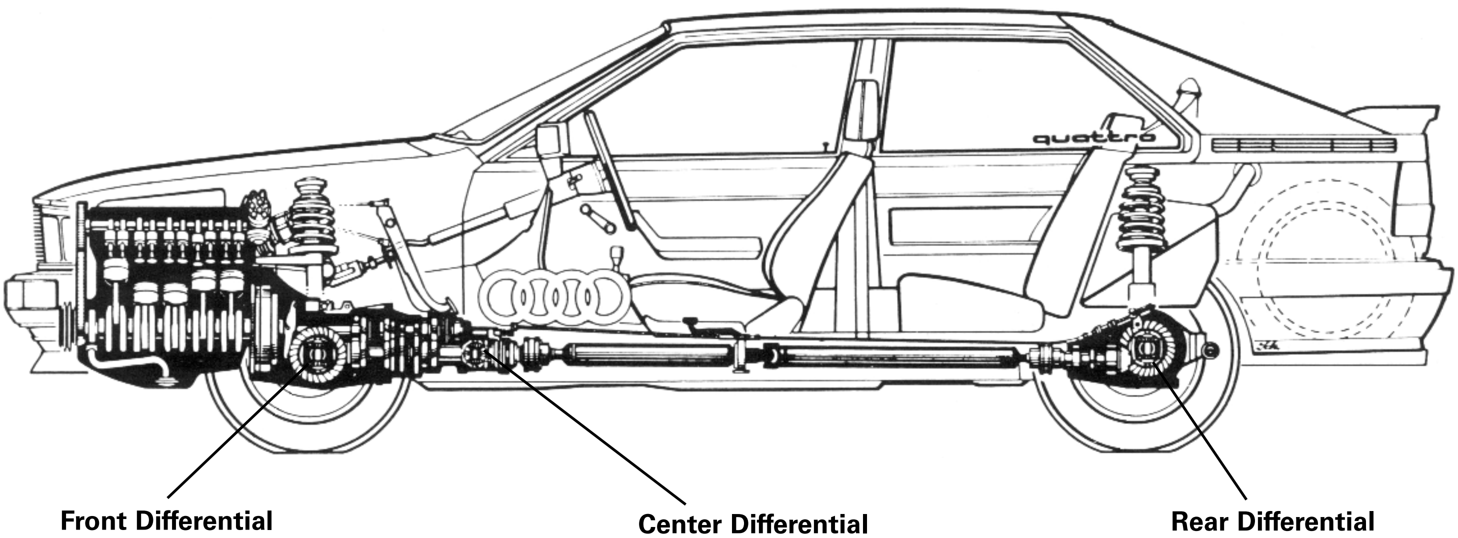
The Audi quattro did not use a transfer case like the other all-wheel or four-wheel drive vehicles of its time. Instead, a central differential was added to the 016 5-speed manual transmission. This design was much lighter than a transfer case.

Three separate differentials were used in the Audi quattro so that each wheel could turn at its own speed when cornering. This reduced power loss and tire life by minimizing "tire scrub."

The all-wheel drive system offered the same advantages back then as it does today:

- Traction on slippery surfaces
- High speed stability
- Traction on steep hills
- Excellent stability under load change conditions

The next page outlines some of the major racing milestones that quattro has achieved.



Introduction to quattro

1980
World premiere of the quattro

At the Geneva Automobile Show, Audi presents a high-performance sports car with permanent all-wheel drive - the Audi quattro. Until this time, only exotic cars produced in very small numbers benefited from the advantages of all-wheel drive.

1981
World premiere of the quattro

Even before its first official rally, the quattro demonstrates its outstanding capabilities. In a European championship run it is used as a route vehicle. With Finn Hannu Mikkola at the wheel, it reaches the finish line half an hour before the winner of the race.

1982
quattro goes into large-scale production

The Audi 80 quattro is the first large-scale production car with all wheel drive. Now, every motorist can profit from the advantages of quattro. Sporting highlights of the year are the victory in the Rally Brand World Championship and the first victory by a woman (Michele Mouton) in a rally world championship run. The Audi quattro is introduced to the North American market.

1983
Hannu Mikkola is driver champion in the Audi quattro

Hannu Mikkola wins the rally driver championship with roaring success and Audi secures second place in the Rally Brand World Championship. A further highlight of the year is the launch of the Audi Sport quattro with an impressive 306 horsepower.

1984

The pioneering work of Audi in all wheel drive technology is recognized with the award titled "Motor Racing Automobile of the Year 1984." The Audi 4000 (Audi 80) quattro is introduced into the North American Market.

1985
Audi takes Pike Peak by Storm

The famous mountain race on Pikes Peak (14,115 ft) in Colorado is won by Michele Mouton in an Audi Sport quattro.

1986
Introduction of the Torsen center differential

The Torsen center differential provides variable, fully automatic and instant distribution of drive torque to the front and rear axles.

1989
Hans Joachim Stuck is the most successful driver of the IMSA-GTO Series

The supremacy of the quattro on fast, asphalt roads had already been demonstrated in the Trans Am Championship the year before. Hans Joachim Stuck was impressive in 1989 with his Audi 90 quattro in the IMSA-GTO Series and becomes the most successful driver of the season with seven victories.

1990
10 Years of quattro

Over 200,000 quattros produced worldwide reflect the success of a revolutionary idea. In October, the Audi Coupe quattro is presented as the successor to the original quattro.

1992
quattro - a principle establishes itself

The motor racing successes of the quattro models increase familiarity and convince more and more motorists of the benefits of quattro. Worldwide, almost every twelfth customer opts for an Audi with permanent four wheel drive during this year.

1993
French Brand and Driver Championships

Audi enters the French touring car championship with the Audi 80 quattro, gaining ten victories and the winning brand championship. With Frank Biela, Audi also wins the French touring car championship.

1994
quattro with EDL

Audi Introduces Electronic Differential Lock (EDL) at the rear axle. The system means that individual wheels can be braked when spinning. In connection with the variable drive torque distribution to the front and rear axle, EDL provides maximum traction.

1996
Audi wins the Touring Car Championship seven times

Audi quattro models enter touring car championships in Germany, Italy, Great Britain, Spain, Australia, and South Africa. At the end of the season, there is only one winner in all of these countries: Audi.

2001
20 years of Quattro

Over 1,000,000 drivers have opted for the benefits of Audi's quattro system.

Introduction to quattro

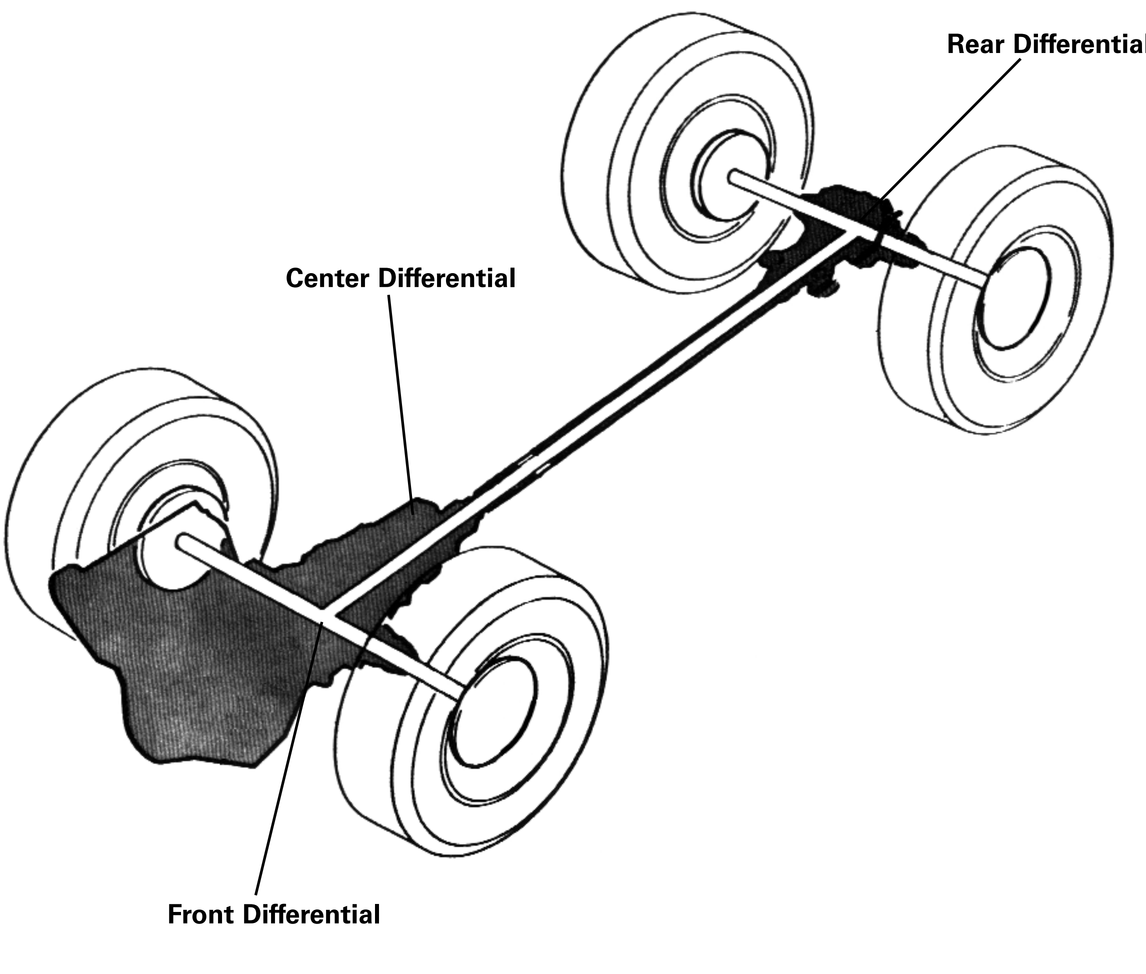
On early quattro models, the center and rear differentials had the capability of being locked manually by the driver.

When the center differential was locked, power would be transmitted equally between the front and rear differentials.

When the center and rear differential were locked, power would be transmitted equally to both rear wheels, causing both rear wheels to turn at the same speed.

With the center and rear differentials locked, the vehicle would have to have three tires spinning before traction would be lost.

The front differential did not have the ability to lock. This is due to the necessity for the front wheels to turn at different speeds. If the front differential were locked, the tires would have to rotate at the same speed and steering would become difficult.

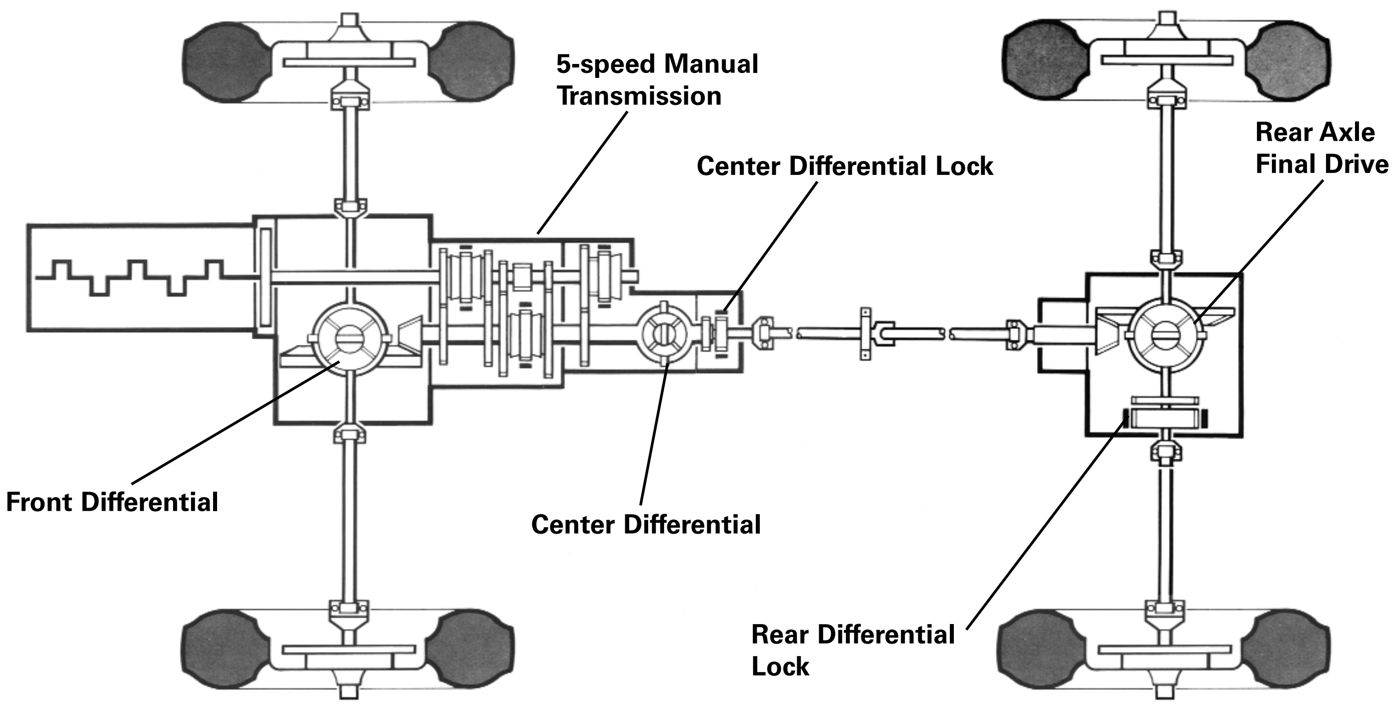


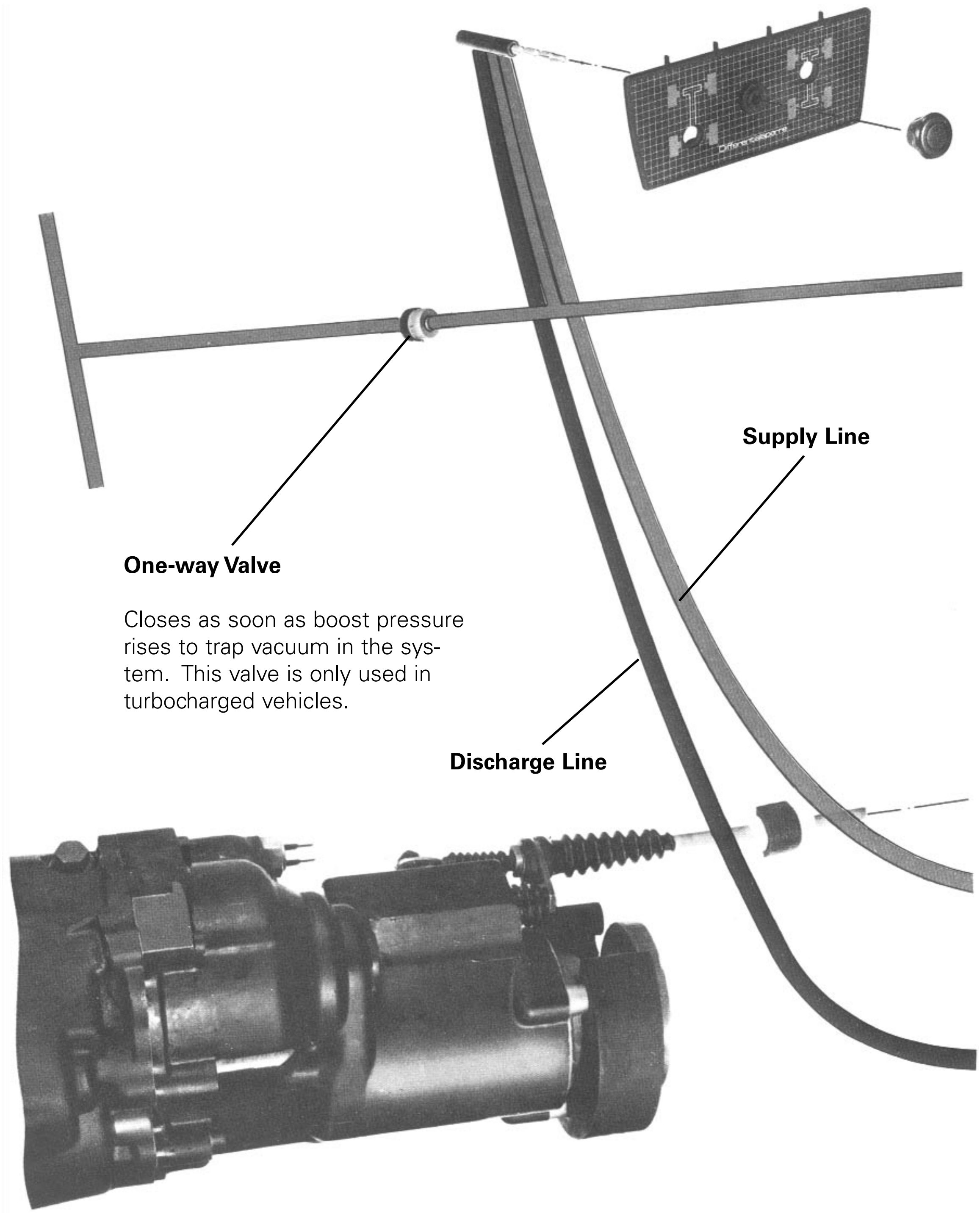
Power was transmitted via the 5-speed manual transmission to the center differential. From the center differential, power was transferred through the drive shaft to the rear final drive.

The pinion shaft also transmitted power from the center differential to the front differential.

Under slippery conditions, the driver could lock either the rear differential or both the center and rear differentials to improve traction.

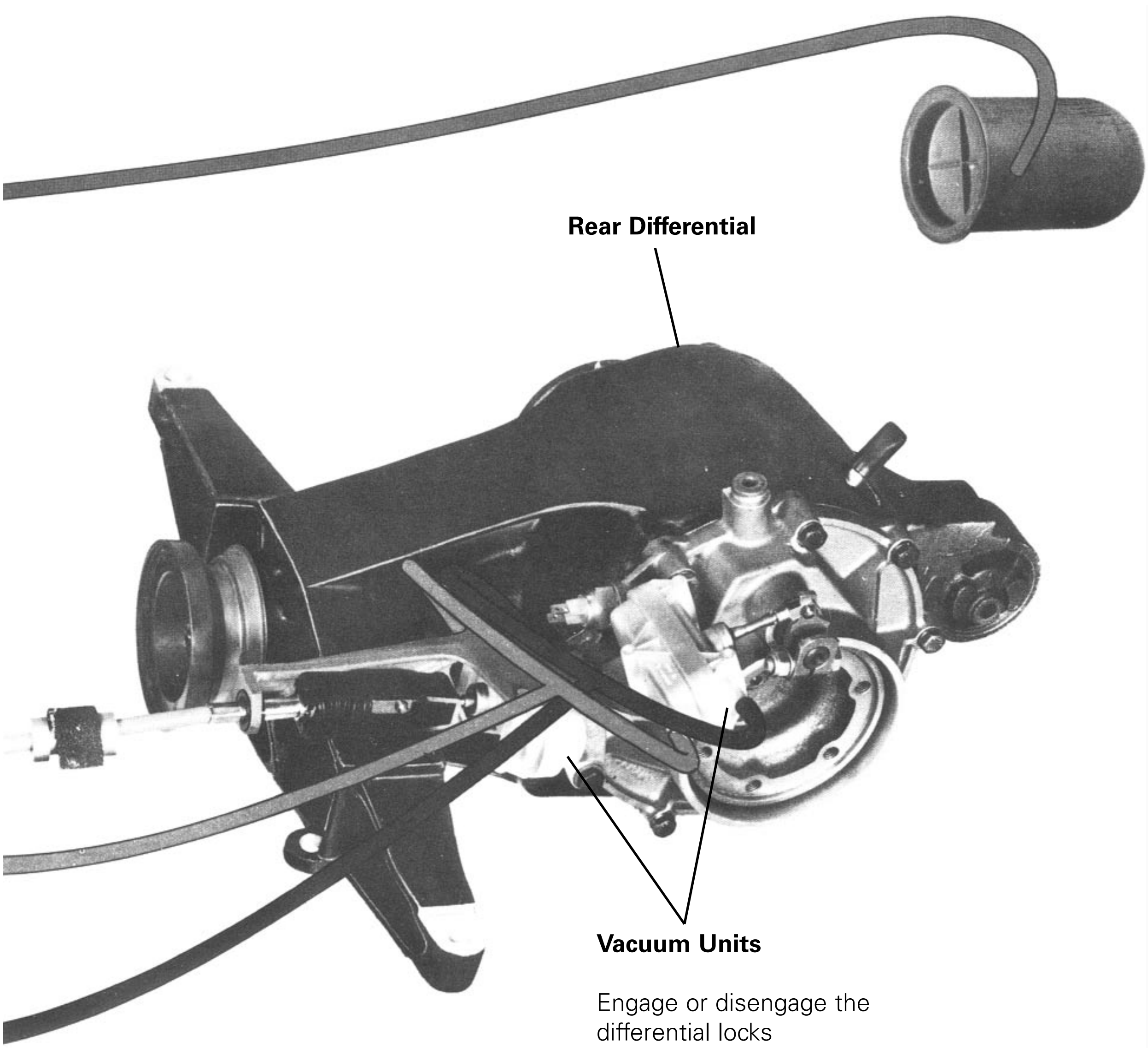
These differential locks could be engaged either when the vehicle was stationary or moving. Two warning lamps on the console indicated when the differentials were locked.




Supply Line
One-way Valve
Closes as soon as boost pressure rises to trap vacuum in the system. This valve is only used in turbocharged vehicles.
Discharge Line

The center and rear differential locks were vacuum operated. When the operating knob was pulled, vacuum was supplied to the engagement side of the vacuum units via the supply line.

When the operating knob was pushed in, the vacuum was transferred to the opposite side of the vacuum unit and the differential locks would disengage.



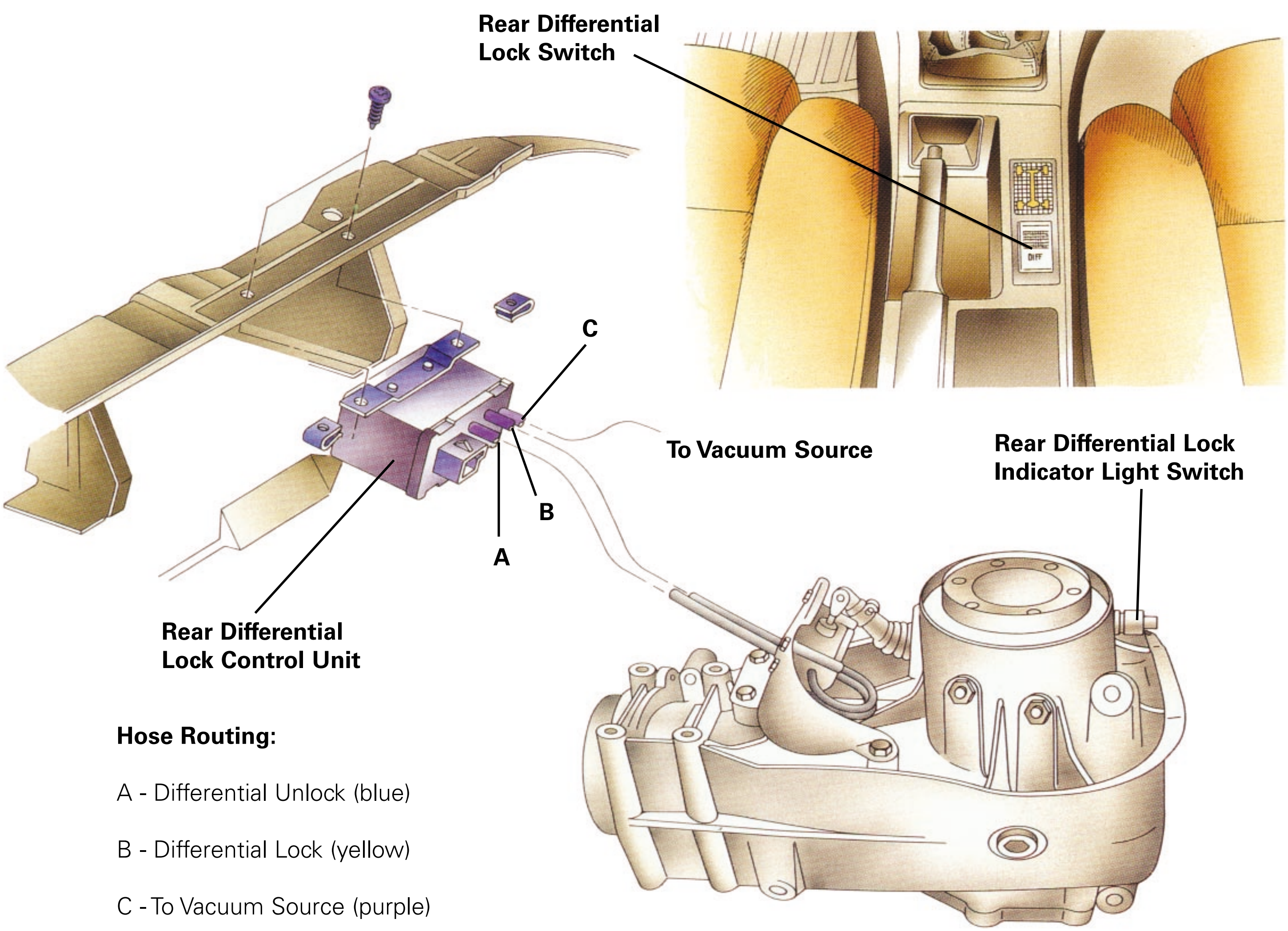
The introduction of the Torsen differential on the Audi 80 and 90 models was the first major change for the quattro system.

The Torsen center differential eliminated the need for driver input to control the center differential. The characteristics of the Torsen differential split the torque 50/50 to the front and rear axles during normal driving conditions.

The Torsen differential also had the ability to automatically change the amount of torque going to each axle based on the amount of traction available.

However, the 80 and 90 models retained a locking rear differential. As in the past, the differential lock was engaged manually. The engagement switch was located on the center console.

An additional feature disengaged the lock automatically when the road speed reached 15 mph (25 km/h). This enabled the vehicle to move off under slippery road conditions without the driver having to remember to disengage the lock once the vehicle started moving. The control unit for this feature was located under the rear seat.



Torsen is a registered trademark of Zexel Torsen Inc. The name Torsen is a combination of the words "torque-sensing". The Torsen concept provides for both the balancing of wheel speeds and the automatic distribution of driving forces between the front and rear axles depending on the torque requirements.

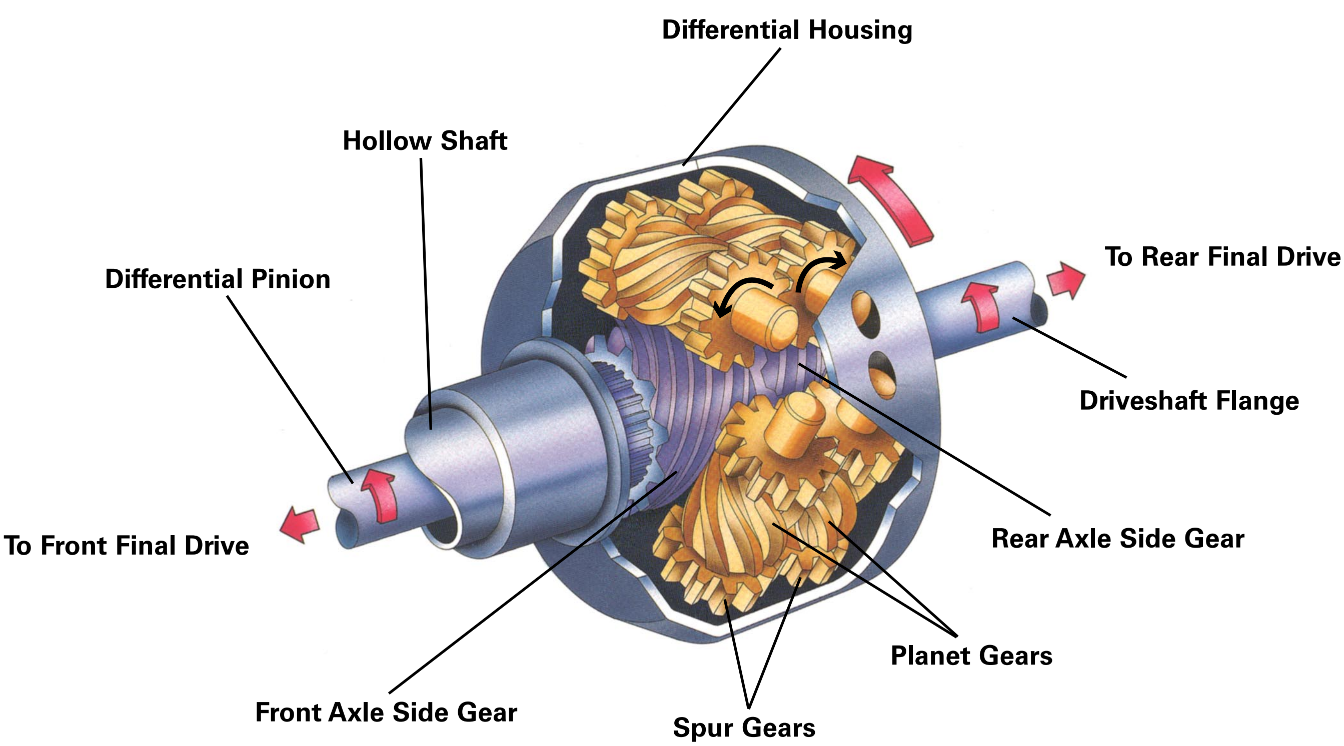
When the vehicle is being driven, the Torsen distributes more torque to the slower turning wheels. This provides a direct and immediate transfer of force to the wheels with greater traction.

Inside the Torsen housing, there are pairs of helical planet gears. The planet gears are held in tight-fitting pockets inside the housing, and are splined together through spur gears at their ends. These spur gears do not allow the planet gears to rotate in the same direction.

The teeth on each of the planet gears mesh with the teeth of one side gear. When the vehicle is moving in a straight line with no slip, the transmission drives the Torsen unit. The Torsen unit in turn drives the planet gears, which drive the side gears.

When an axle loses traction, the planet gears, through the spur gears, are responsible for the power transfer.

The interlocked planet gears will apply even force to each side gear. Only the planet gear meshed to the side gear that has traction can apply this force. The other planet gear is simply following along.



Early Rear Differential Torsen Design

Torsen Differential

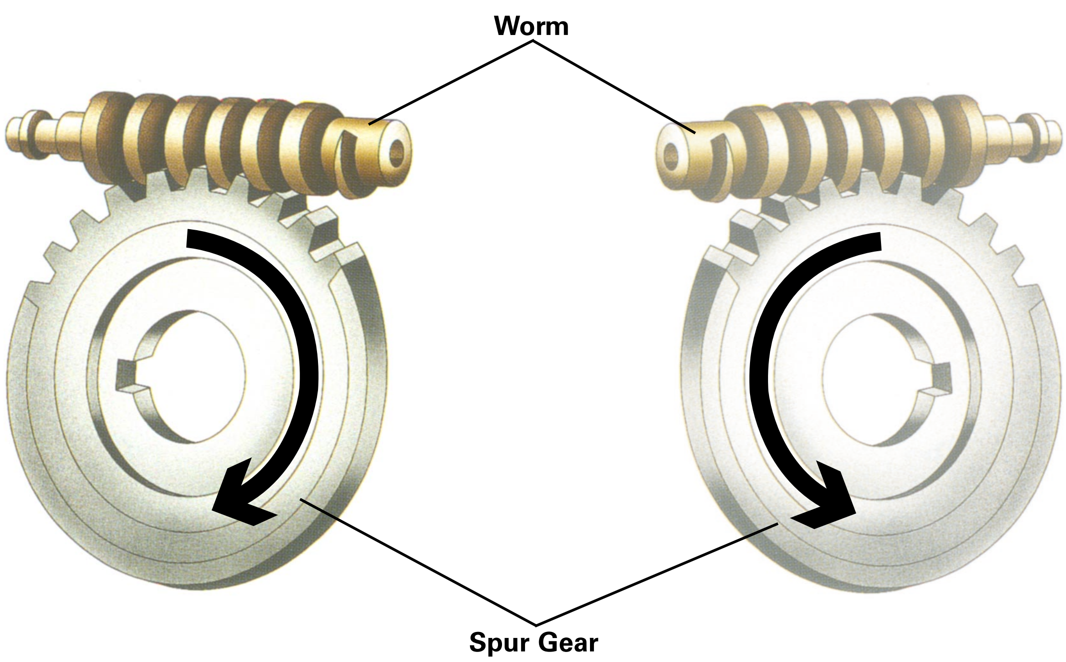
The angle and shape of the helical planet and side gears determine the maximum amount of power that can be sent to the axle with better traction. This is determined by the locking value of the gears.

The locking value of the differential is dependent on the angle at which the teeth of the planet gear meet the teeth of the side gear, and the amount of pressure on the side gear. The more inclined the tooth angle, the lower the locking value. The less inclined the tooth angle, the higher the locking value.

Because of the unique torque distributing characteristics of the Torsen differential, the need for the center differential lock was eliminated.

The maximum amount of power is referred to as the Torque Bias Ratio (TBR). The TBR for the Torsen differential is about 2:1.

This means that about two-thirds of the torque, or about 67%, can be sent to the axle with better traction. The remaining third continues to flow to the axle with less traction.



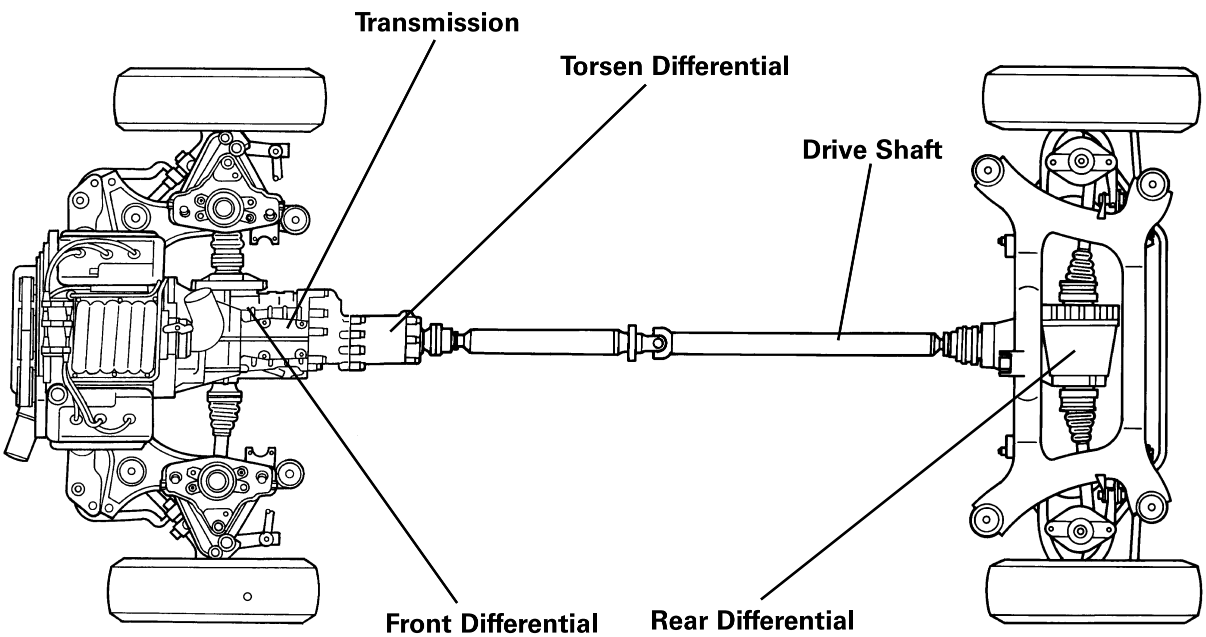
Spur Gear Driving Worm Gear

Worm Gear Driving Spur Gear

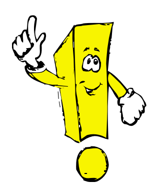
The biggest advantage to the Torsen differential is that it works without driver input. There are no electrical connections or computer controls.

The Torsen differential is fully automatic and does not require driver input to lock or unlock the center differential.

Under normal conditions, the torque split is 50% front and 50% rear.



The Audi V8 used two separate Torsen units. One was used as a center differential and one was used as a rear differential to control wheel slip on that axle.



Models with a standard rear differential use Electronic Differential Lock (EDL) as a means to control wheel slip. More information about EDL is located on page 39 of this SSP.

Haldex Coupling

The development of the Haldex coupling is a giant step forward in modern all-wheel-drive technology. The Haldex coupling is controllable, based on the inputs the Haldex control module receives from the vehicle.

Slip is no longer the only decisive factor in the distribution of drive forces; the car's dynamic state is also a factor. The Haldex control module monitors the ABS wheel speed sensors and the engine control module (accelerator pedal signal) via the CAN bus. This data provides the control module with all the information it needs on road speed, cornering, coasting or traction mode, and can respond optimally to any driving situation.

Characteristics of the Haldex coupling:

- Permanent all-wheel drive with electronically controlled multi-plate clutch
- Front drive characteristic
- Quick response
- No strain on clutch when parking and maneuvering vehicle
- Compatible with different tires (e.g. emergency wheel)
- No restrictions on towing with the rear axle on the ground
- Fully combinable with systems such as the anti-lock brake system (ABS), the electronic differential lock (EDL), the anti-slip regulation (ASR), the electronic brake distribution system (EBD) and electronic stabilization program (ESP)

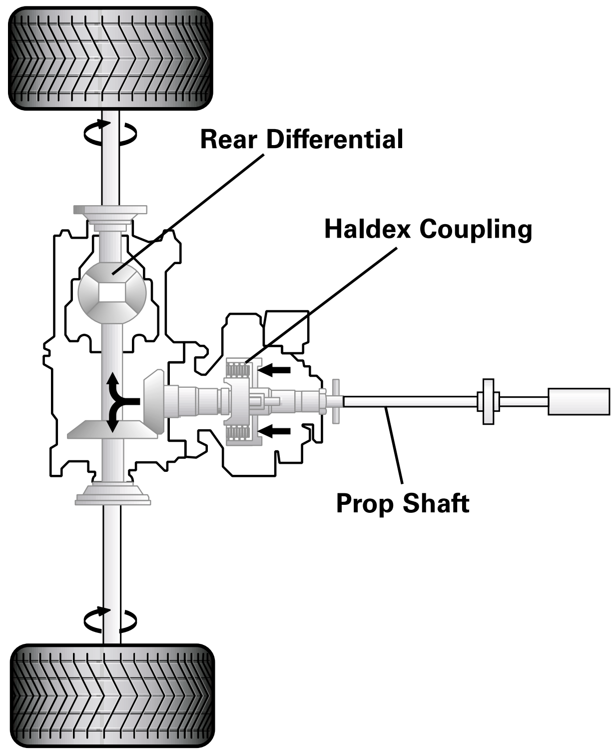
Haldex Coupling

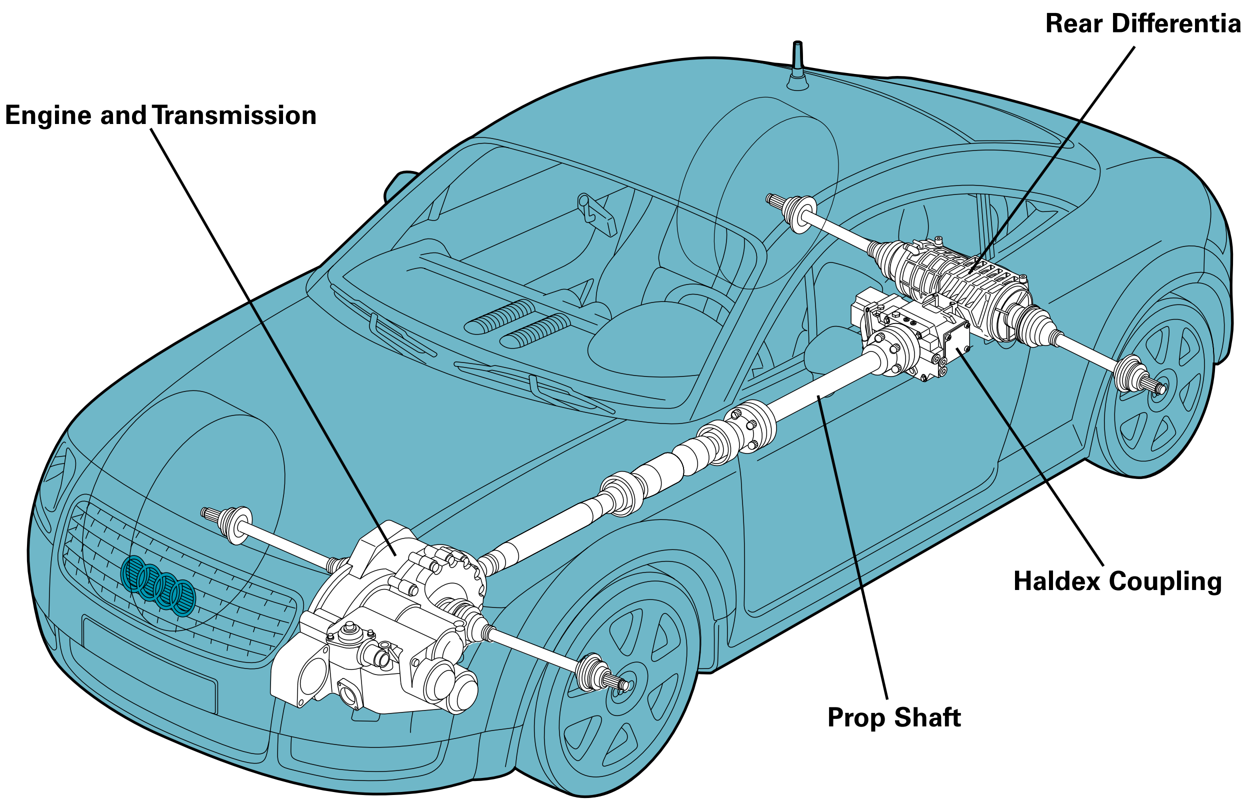
The Haldex coupling is mounted on the rear axle differential and is driven by the prop shaft.

Engine torque is transmitted to the prop shaft through the gearbox, the front axle differential and the front axle drive.

The prop shaft is connected to the input shaft of the Haldex coupling. In the Haldex coupling, the input shaft is separated from the output shaft to the rear axle differential.

Torque can only be transmitted to the rear axle differential when the Haldex coupling clutch plates are engaged.

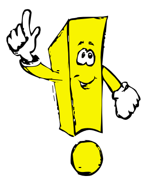




Haldex System

The parts include:

- the input shaft
- the inner and outer clutch plates
- the lifting plate
- the roller bearing with annular piston
- the output shaft



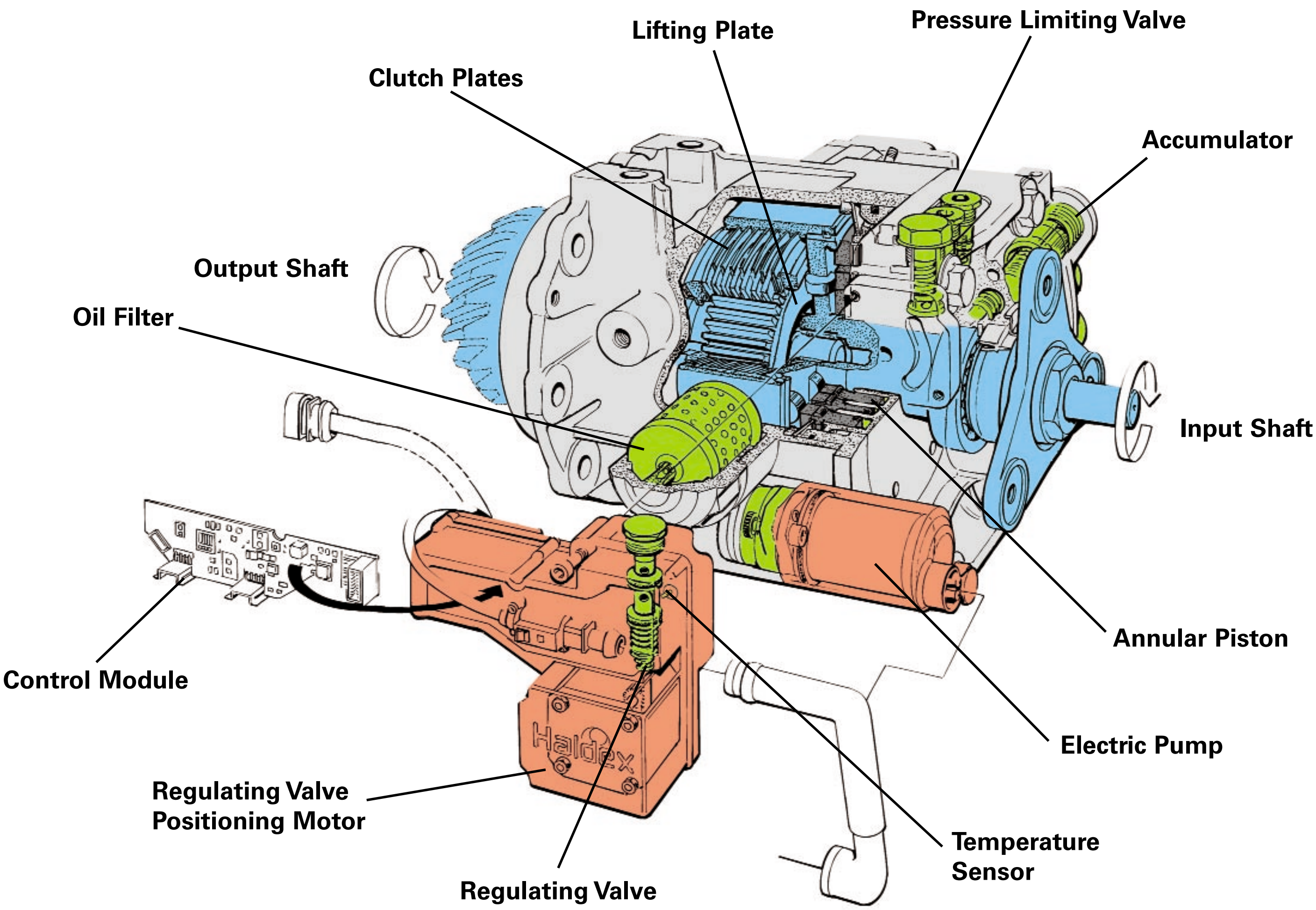
The Haldex oil and oil filter must be replaced every 20,000 miles (32,000 km). Refer to AESIS for the latest maintenance schedules and service procedures

The electronics are:

- the pump for Haldex coupling
- the regulating valve positioning motor
- the temperature sensor
- the Haldex control module

The hydraulics are:

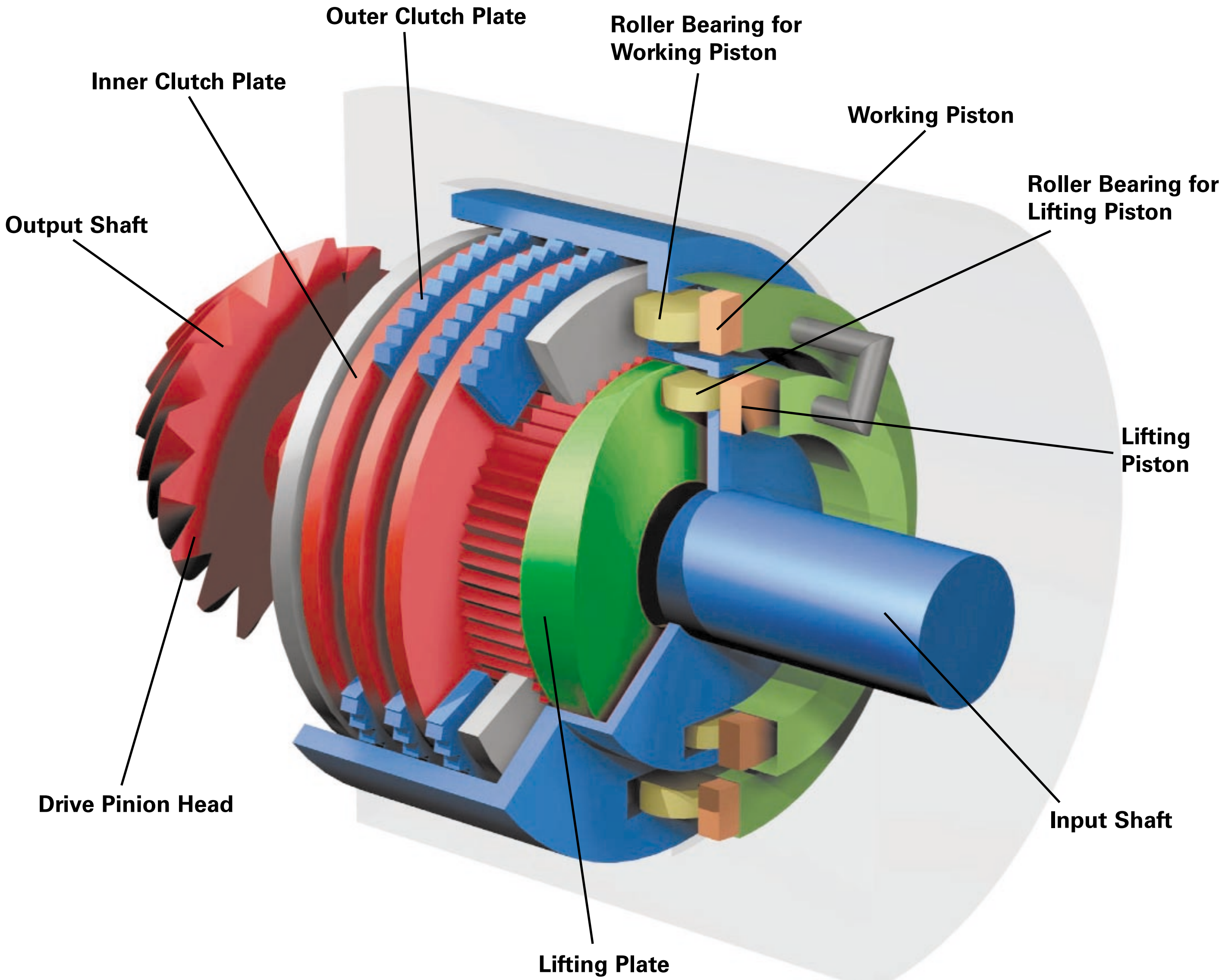
- the pressure valves
- the accumulator
- the oil filter
- the annular piston
- the regulating valve



The Multi-plate Clutch

The clutch input shaft, indicated in blue in the figure, is connected to the prop shaft. The roller bearings for the lifting piston and the working piston, as well as the outer clutch plates, are engaged when the input shaft rotates.

The lifting and working pistons are annular pistons. The output shaft, indicated in red in the figure, forms a unit from the lifting plate through to the drive pinion head. The inner clutch plates are also connected to the output shaft via longitudinal toothing.



Disengaged Haldex Clutch Assembly

Function

When a speed difference is present between the input and output shafts, the input shaft, together with the roller bearing of the lifting piston, rotates around the still stationary lifting plate of the output shaft.

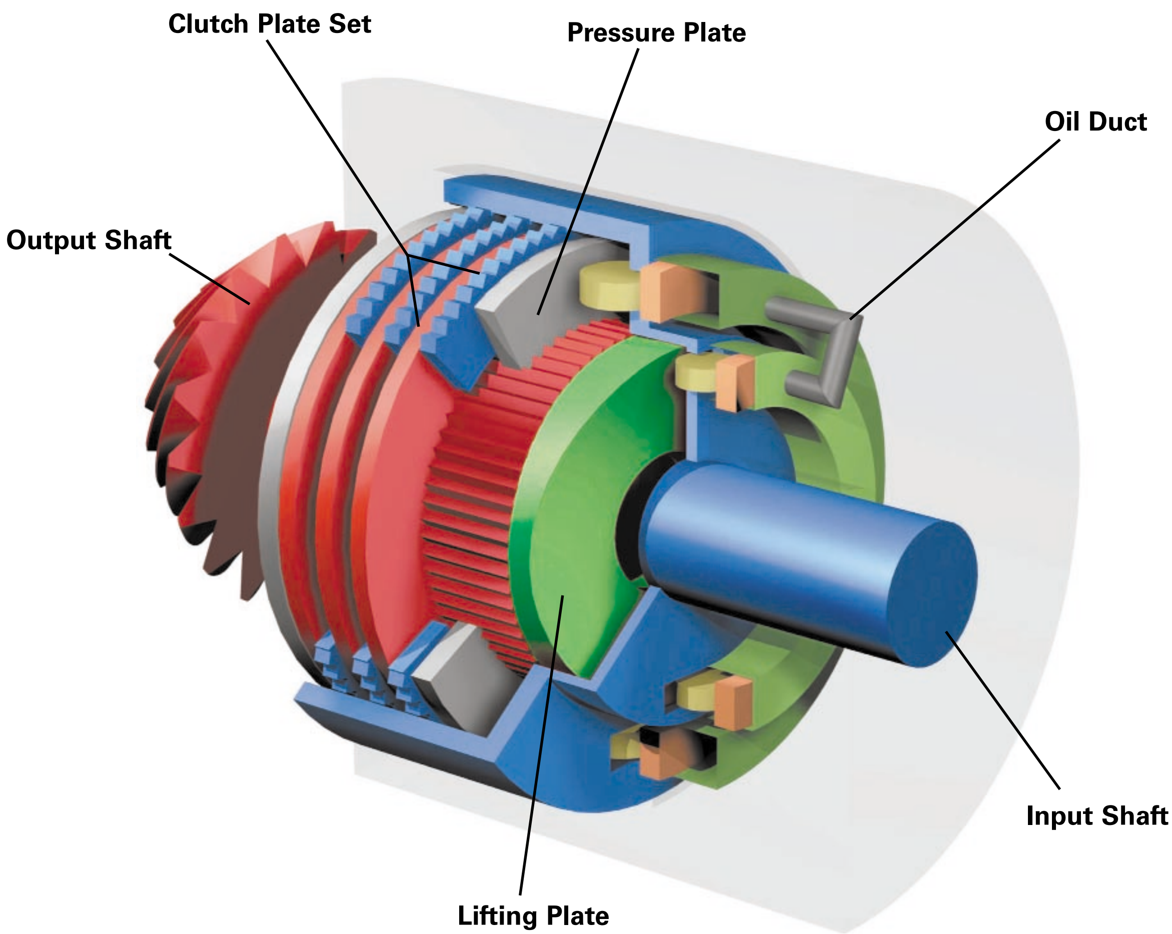
The roller bearing of the lifting piston tracks along the undulating surface of the lifting plate. The roller transfers these upward and downward movements to the lifting piston.

This causes the lifting piston to perform a lift movement, building up oil pressure.

This oil pressure is diverted via an oil duct to the working piston. The oil pressure forces the working piston to move to the left against the bearing roller and the pressure plate of the clutch plate set.

The clutch plate set is compressed.

The input shaft and the output shaft of the clutch are now interconnected, connecting both the front and rear axles and making all-wheel drive possible.

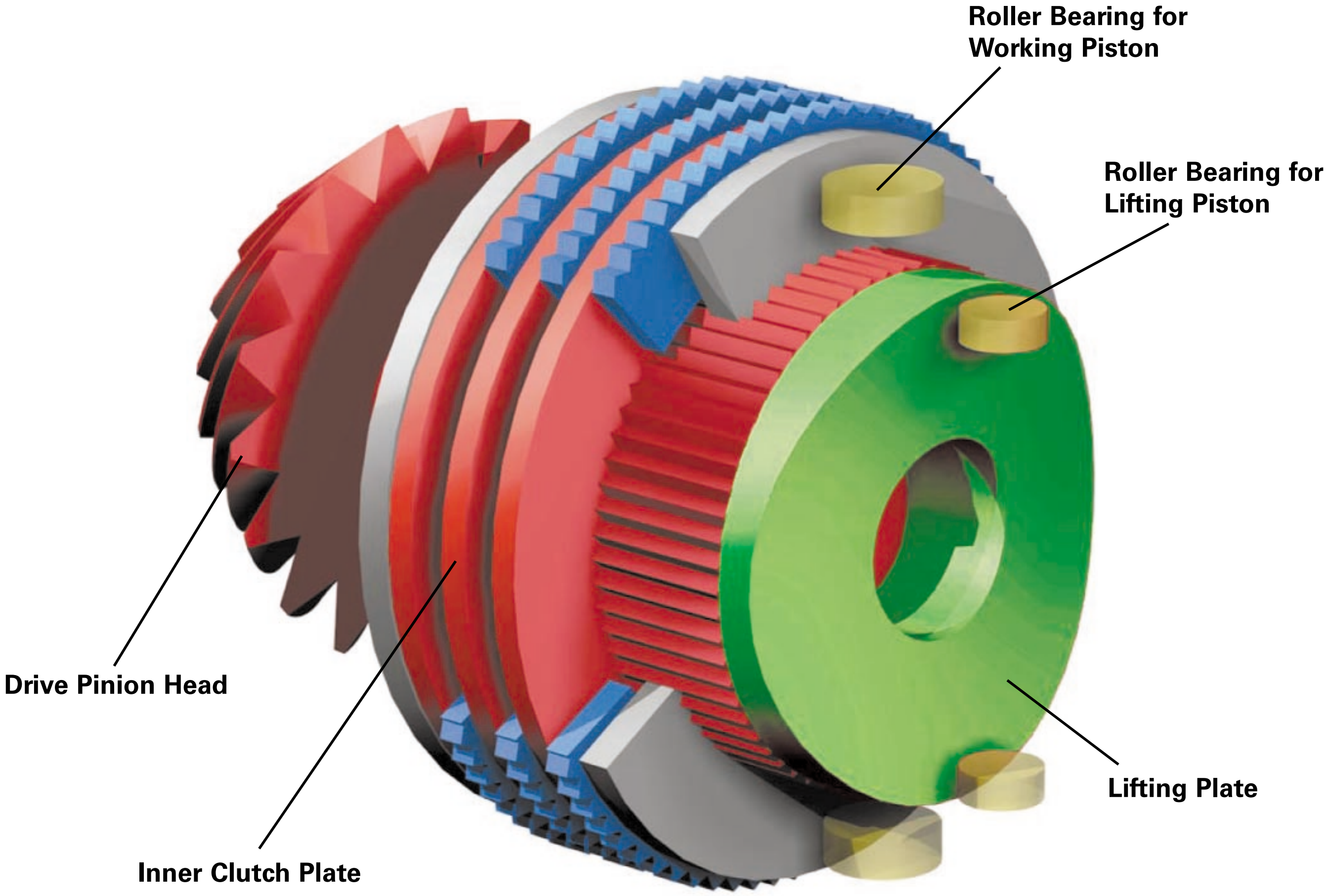


Engaged Haldex Clutch Assembly

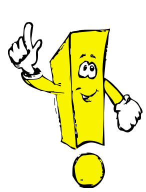
When a difference in speeds occurs between the front and rear axles, the outer clutch plate housing, together with the roller bearings, rotates around the output shaft in such a way that the roller bearings of the lifting piston roll on the lifting plate.

Due to the shape of the lifting plate, the roller bearings of the lifting piston follow an undulating path and transfer the lifting movement to the lifting pistons in the housing.

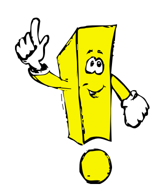
The output shaft, with its splines for the inner clutch plate, combines with the lifting plate and the drive pinion head to form a unit.



Engaged Haldex Clutch Assembly



The roller bearings are shown here for your information only.

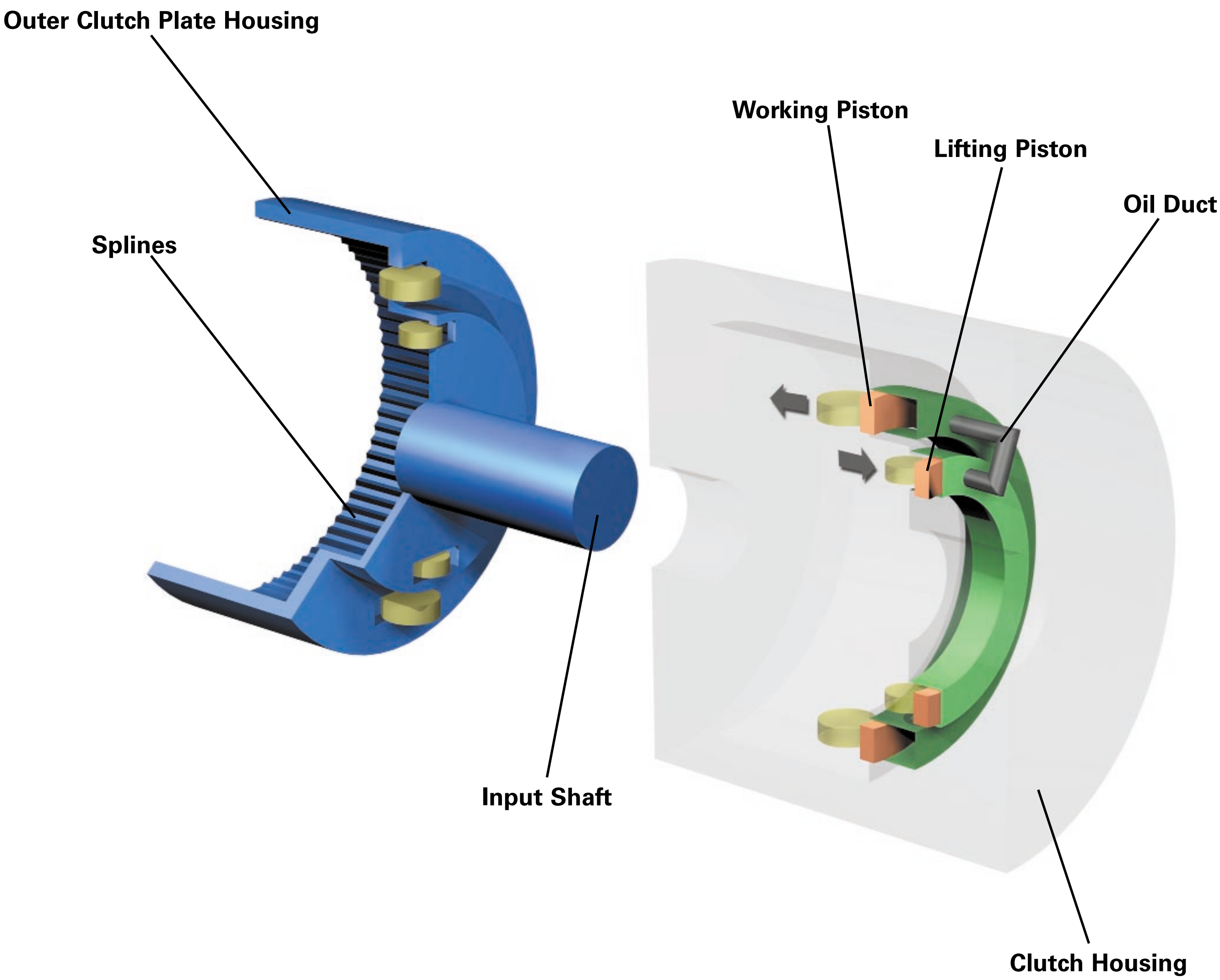


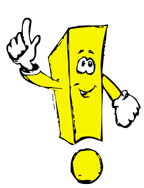
For reasons of clarity, we have shown the lifting plate with two cams. In reality, however, there are three cams on the lifting plate. The function remains unchanged.

The outer clutch plate housing, together with the splines for the outer clutch plate and the roller bearing form, combines with the input shaft to form a unit.

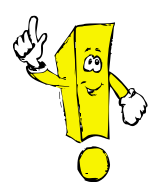
The lifting movement of the lifting piston produces an oil pressure which acts on the working piston via the oil duct and pushes the piston to the left.

The pressure is transferred via a pressure plate to the clutch plate set via the roller bearings of the working piston. The clutch closes and thus interconnects the front and rear axles.





The roller bearings are located in the outer clutch plate housing, as shown here.



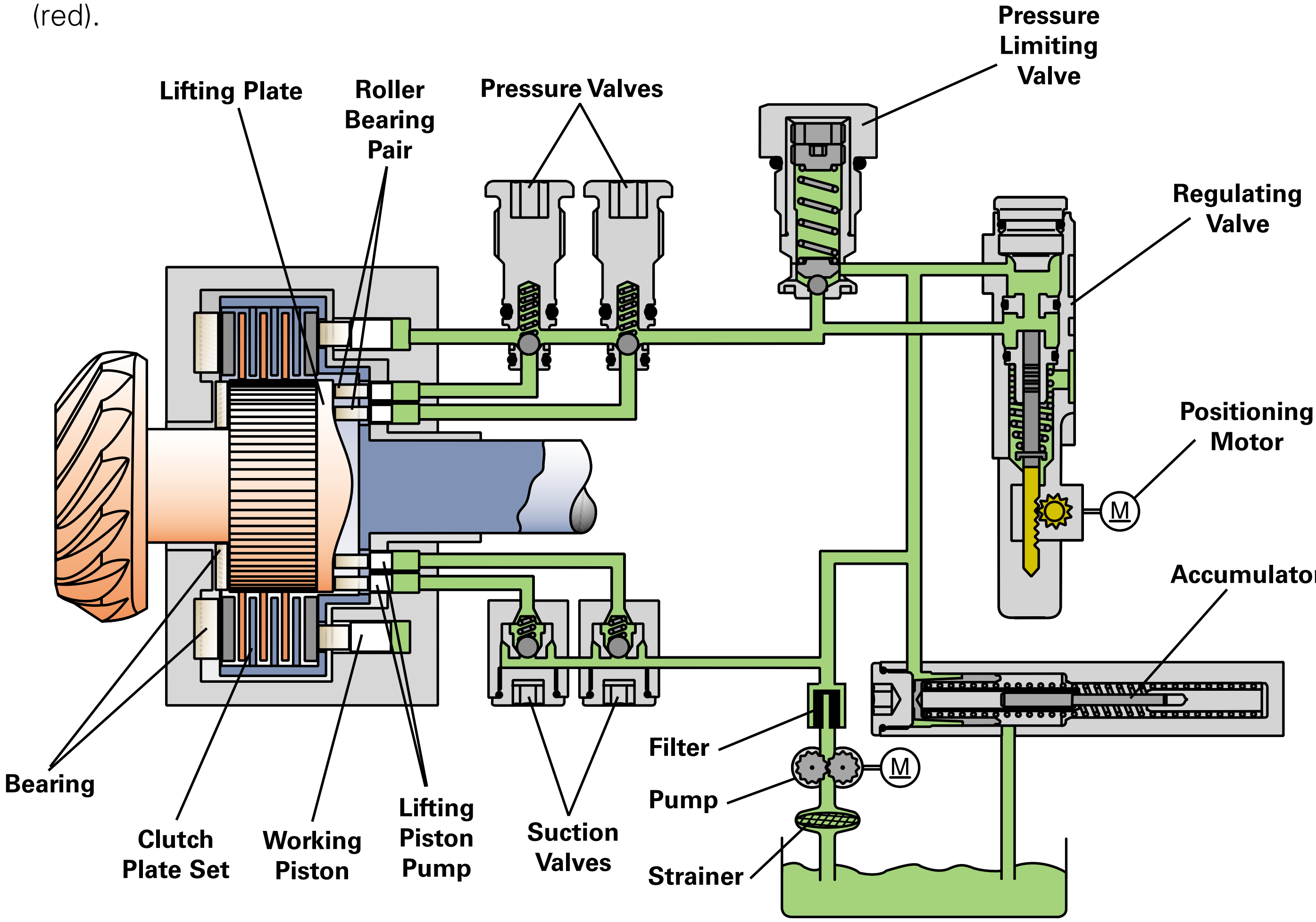
The roller bearings are shown here for your information only.

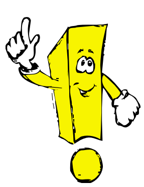
Diagram of Oil Pressure System

The pressure limiting valve determines the maximum pressure on the clutch plates.

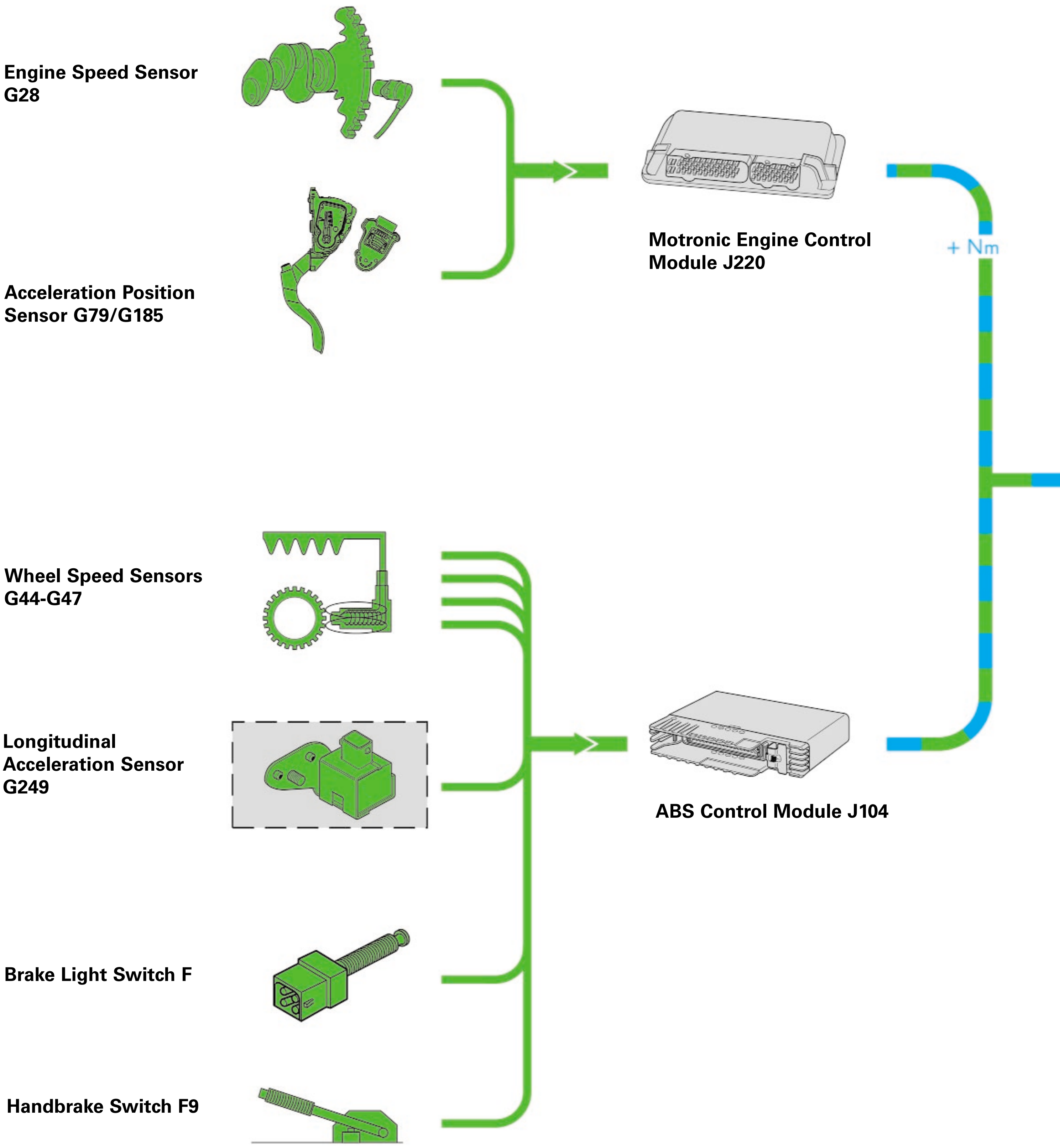
You have already seen how oil pressure is built up at the lifting piston as a result of a difference in speeds between the input shaft (blue) and the output shaft with lifting plate (red).

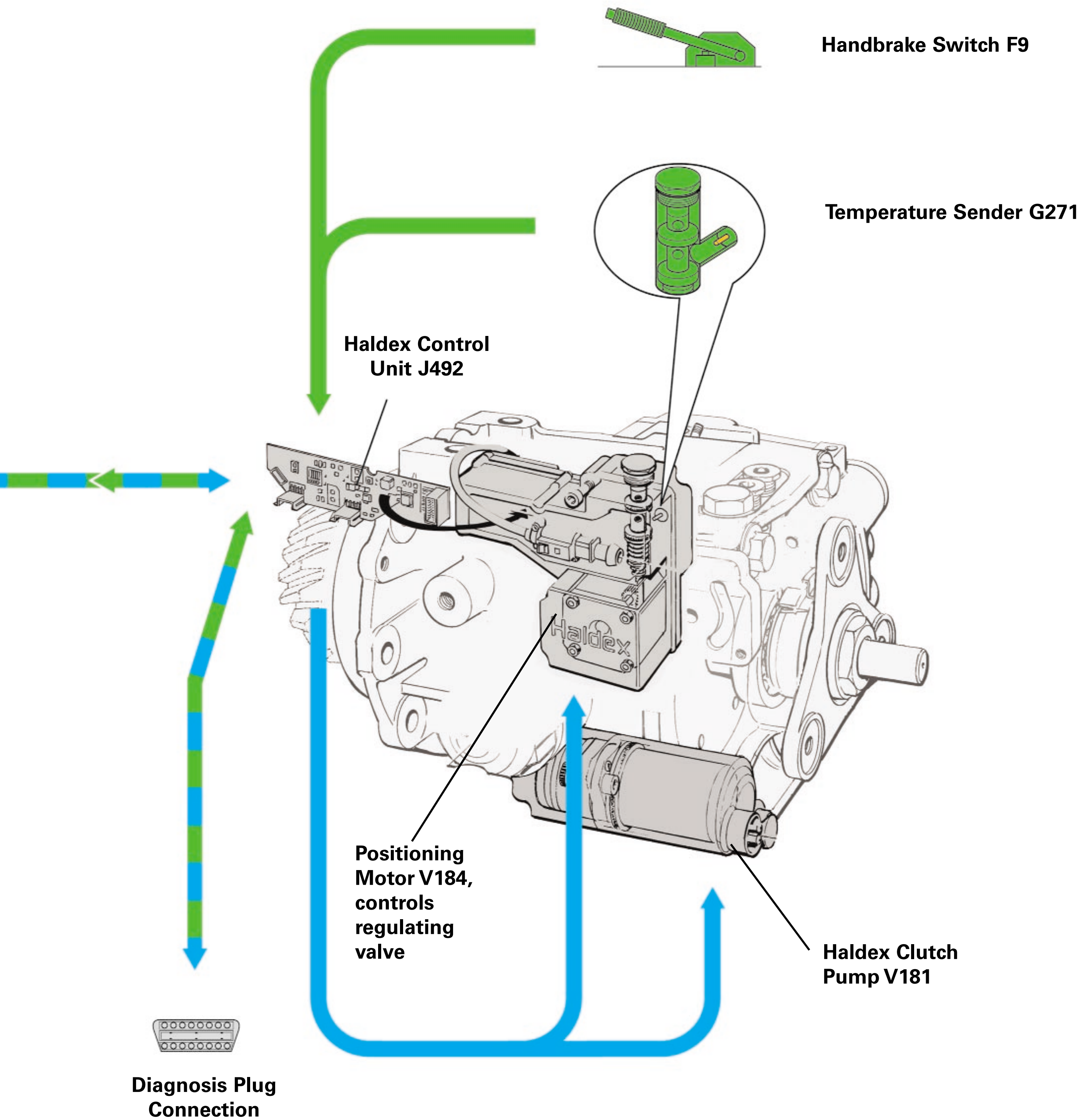
This oil pressure is regulated by valves. The plate clutch can thus allow a certain amount of slip when open and nearly closed.





For reasons of clarity, we explained the function on the previous pages using a lifting piston by way of an example. In reality, there are two lifting pistons in the clutch housing; these pistons are actuated by roller bearing pairs. Therefore, two suction valves and two pressure valves are also required.


Engine Speed Sensor G28
Acceleration Position Sensor G79/G185
Motronic Engine Control Module J220
+ Nm
Wheel Speed Sensors G44-G47
Longitudinal Acceleration Sensor G249
ABS Control Module J104
Brake Light Switch F
Handbrake Switch F9


Handbrake Switch F9
Temperature Sender G271
Haldex Control Unit J492
Positioning Motor V184, controls regulating valve
Haldex Clutch Pump V181
Diagnosis Plug Connection

The Motronic Engine Control Module

The Motronic engine control module (ECM) is mounted in different areas on the various vehicles, but is normally accommodated in the plenum chamber. The operating mode of the Motronic ECM is torque-oriented.

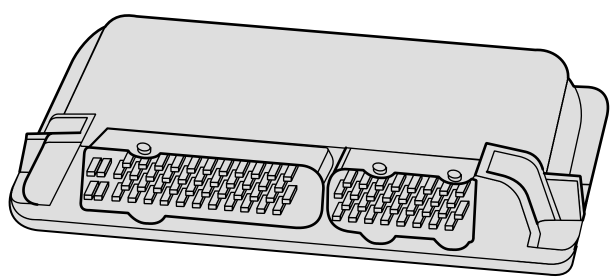
Signal utilization for the all-wheel drive electronics

The Motronic ECM provides the following signals to the Haldex control module along the CAN bus:

- Engine speed signal
- Accelerator pedal position
- Engine torque

Effects of signal failure:

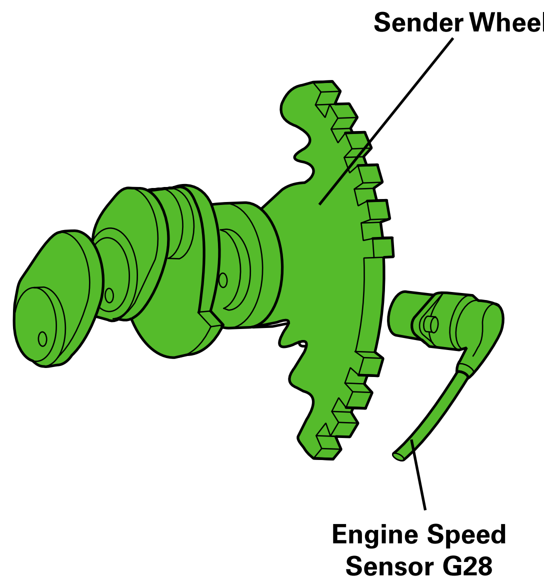
- The Haldex unit will not operate



Motronic Engine Control Module J220

Engine Speed Sensor G28

The engine speed sensor is an inductive sensor and is installed near the the oil filter on the left-hand side of the engine.



Signal utilization

The sensor records the exact angular position of the crankshaft to determine the ignition and injection point, as well as engine speed.

Engine speed

As soon as the engine turns, the sensor wheel moves past G28 and generates an alternating current (AC) voltage. The frequency and amplitude of this voltage changes with engine speed.

The Motronic ECM calculates the engine speed from the frequency of the AC voltage.

Ignition point

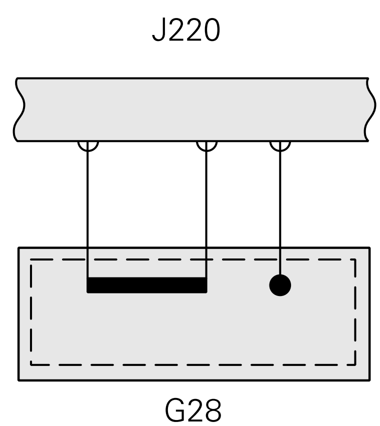
For recognizing the crankshaft position, the wheel has a larger gap trigger tooth which serves as a reference mark.

Effects of signal failure

If the engine speed signal supplied by the engine speed sensor fails, the engine will not be started or run.

If no engine speed signal is received, the Haldex control module will not energize the pump, leaving the rear axle drive capability disabled. This also allows the vehicle to be towed with the rear wheels on the ground. No power will be transmitted back through the wheels to the transmission.

Electrical circuit



Throttle Position Sensor G79/G185

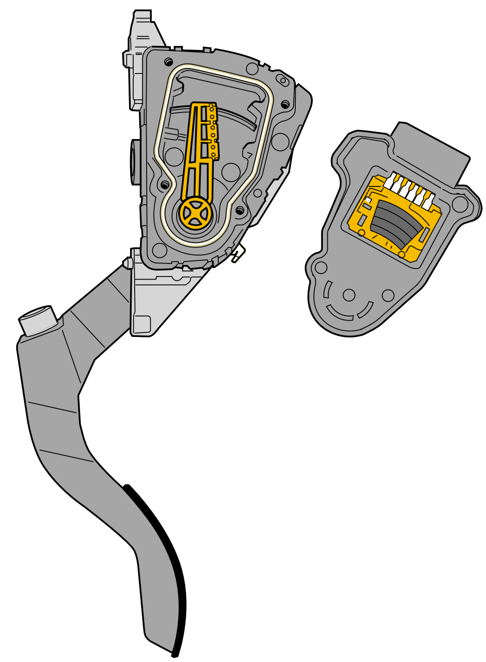
The throttle position sensor sends an analog signal corresponding to the accelerator pedal position to the Motronic ECM. Two independent potentiometers, G79 and G185, make up the throttle position sensor.

The Haldex control module uses this signal in combination with other signals to determine when and how much power should be applied to the rear axle. The throttle position sensor represents the driver intention, and is not necessarily how the Motronic ECM is allowing the engine to operate.

Effects of signal failure

The Motronic ECM monitors G79 and G185 for proper functioning and plausibility. If one of the two sensors fails, the other sensor acts as a back-up. The warning lamp K132 on the instrument panel will illuminate and the vehicle will enter emergency running mode.

If this signal is not available to the Haldex control module, all-wheel drive will not be available.

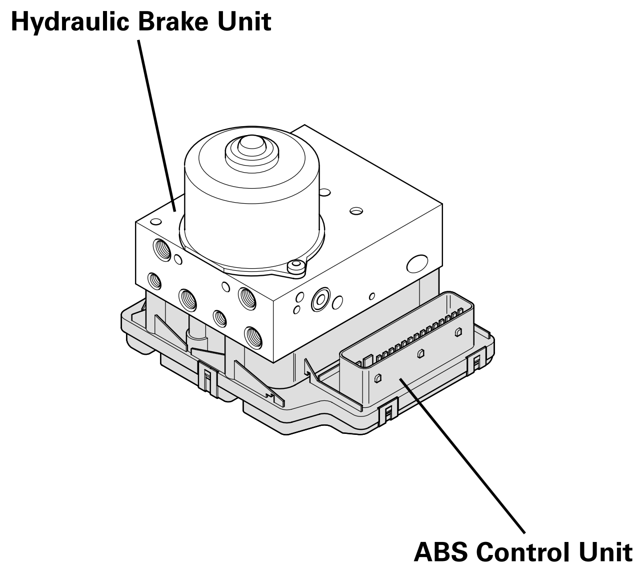


Throttle Pedal Position Sensor G79/G185

ABS Control Module J104

The anti-lock brake system (ABS) control module (by ITT Automotive) is combined with the hydraulic unit as a module and mounted in the engine compartment on the left-hand side.

When the ignition is turned on, the control modules carry out a self-test. The control module consists of two processor systems. This ensures a high level of fail-safety. In addition to monitoring individual components, the two processor systems monitor each other.



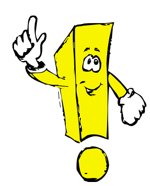
Signal utilization for all-wheel-drive electronics

The following signals are supplied to the Haldex control module along the CAN bus:

- Wheel speed sensor
- Brake light switch
- Handbrake switch
- Longitudinal acceleration sensor

Effects of signal failure

In the unlikely event of total failure of the control module, the Haldex unit will not function properly.



If the vehicle also has the electronic stabilization program (ESP), then ESP control takes precedence over the all-wheel drive function.

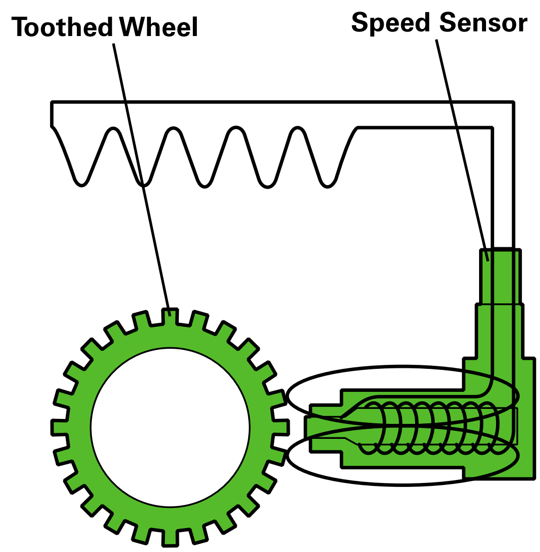
Wheel speed sensors G44 - G47

The wheel speed sensor detects the change in speed of the wheel and sends this information to the ABS control module in the form of wheel speed information. This information is then sent to the Haldex control module via CAN-bus.

The wheel speed sensor is mounted in the vicinity of the axle flange. A toothed wheel is positioned on the axle flange in such a way that it moves past the top end of the wheel speed sensor when the wheel rotates.

Magnetic lines of force between the tooth and tooth gap of the toothed wheel are distorted. This induces a sine-wave AC voltage in the coil of the engine speed sensor.

The frequency and amplitude in the coil is dependent on the wheel speed. The ABS control module calculates the momentary speed of individual wheels from the frequency.



Wheel Speed Sensor

Effects of signal failure

- No ABS control
- No four-wheel-drive control

Longitudinal Acceleration Sensor G249

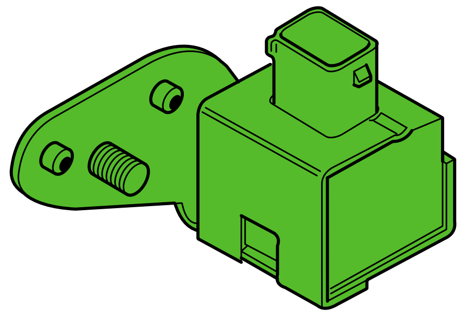
The longitudinal acceleration sensor G249 is attached to the right side A pillar.

On vehicles that are driven at one axle only, the system calculates the vehicle's longitudinal acceleration from the data supplied by the Sensor -2- for Brake Pressure G214, the signals supplied by the ABS wheel speed sensors and information from the engine management system.

On four-wheel drive vehicles with the Haldex coupling, the front and rear wheels are connected when the coupling is closed. The calculated true vehicle road speed, which is determined from the individual wheel speeds, may be too inaccurate under certain conditions at low coefficients of friction and when the Haldex coupling is closed. The longitudinal acceleration measured is used to verify calculated road speed.

Effects of signal failure

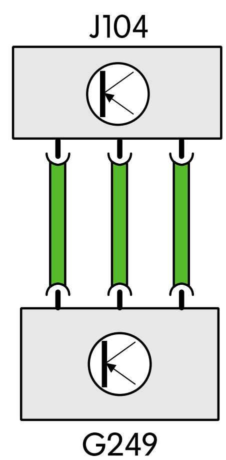
Without the additional measurement of longitudinal acceleration, it is not possible to determine the true vehicle road speed exactly in unfavorable conditions. As a result, the electronic stability program (ESP) and anti-slip regulation system (ASR) will not operate.



Longitudinal Acceleration Sensor

Electrical circuit

The longitudinal acceleration senor is connected to the control unit J104 via three lines.



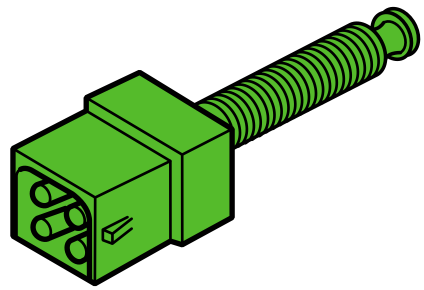
Brake Light Switch F

Brake light switch F is located at the upper end of the brake pedal and is secured to the pedal support.

Signal utilization

The brake light switch sends the "brake activated" signal to ABS control module J104. The control unit informs the Haldex control module along the CAN bus.

When the brake is applied, the Haldex control module immediately opens the pressure regulator via the positioning motor and the Haldex coupling clutch is opened.

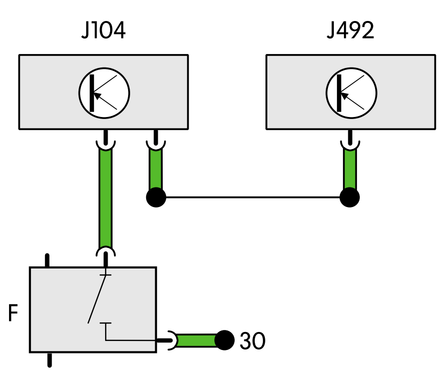


Brake Light Switch

Effect of signal failure

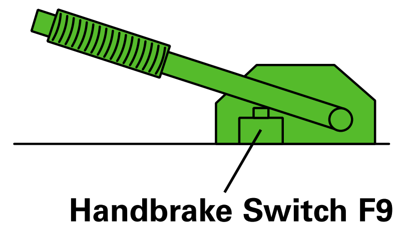
The information provided by the CAN bus is used as an alternative.

Electrical circuit



Handbrake Switch F9

Handbrake switch F9 is located under the hand brake lever.



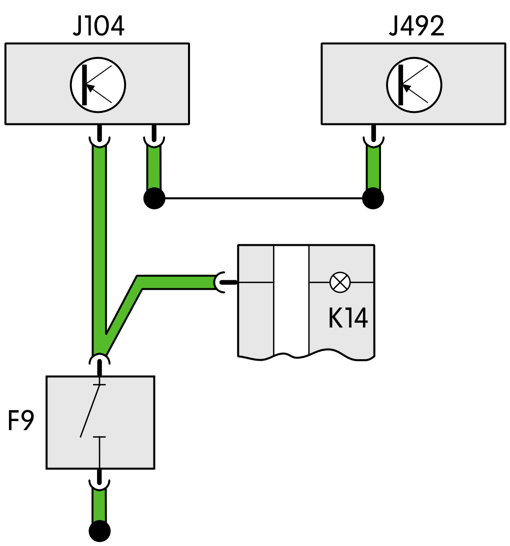
Signal utilization

The handbrake switch sends the "handbrake engaged" signal to the ABS control module J104 and simultaneously to the Haldex control module J492.

Whereas the ABS control module transfers this information to the Haldex control unit in "filtered" form along the CAN bus, the Haldex control module also receives the information directly from the handbrake switch.

If the signal generated by handbrake switch F9 is picked up, the Haldex coupling clutch is opened.

Electrical circuit

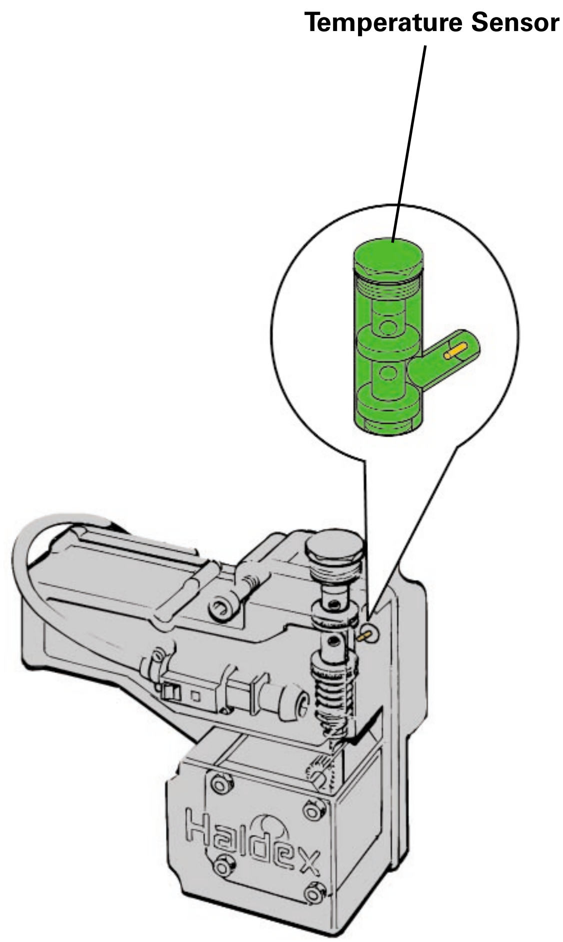


Effects of signal failure

If the switch remains closed, then no all-wheel drive control is available and restrictions are placed on ABS control.

Haldex Coupling Temperature Sensor G271

The Haldex coupling temperature sensor is installed near the regulating valve in the Haldex control module housing and is immersed in hydraulic fluid.



Signal utilization

The temperature sensor senses the momentary hydraulic oil temperature and sends this information to the Haldex control module. This information is used for adapting to the changing viscosity of the hydraulic fluid.

If the hydraulic fluid temperature exceeds 100°C, the clutch is released. If the temperature of the hydraulic fluid drops below 100°C, the clutch is again pressurized.

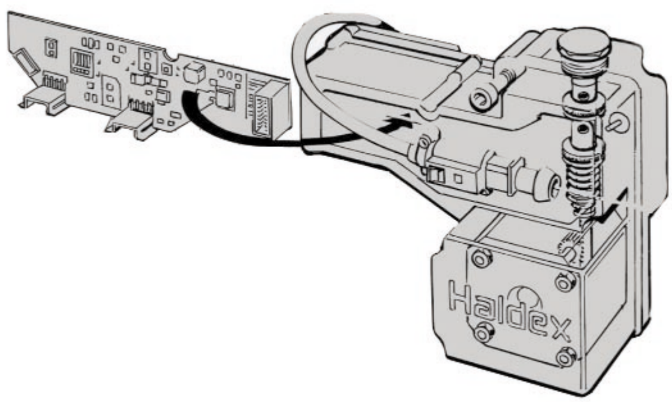
Effects of signal failure

All-wheel drive is shut off if no signal is received from the temperature sensor G271.

Temperature	Hydraulic Fluid/Viscosity	Regulating Valve
In the minus range	High viscosity	Slightly more open
Normally 20° C	Normal	Normally open
Over 20° C	Low viscosity	Slightly less open

Haldex Control Module J492

The Haldex control module is mounted directly on the housing of the Haldex coupling and combines with the positioning motor and the regulating valve to form a unit.



Haldex Control Module J492

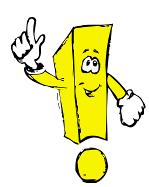
Design and function

The Haldex coupling control module is connected to the engine and the ABS control unit via the CAN bus. From the signals that are generated by the Motronic ECM sensors, the Haldex control module decides what oil pressure to apply to the plates of the Haldex coupling clutch.

The oil pressure acting on the plates of the Haldex coupling clutch determine what torque is to be transmitted to the rear axle.

Effects of signal failure

If the Haldex control module is not operating correctly, no all-wheel drive is possible.



The address word to access the Haldex Control Module is 22.

Positioning Motor V184

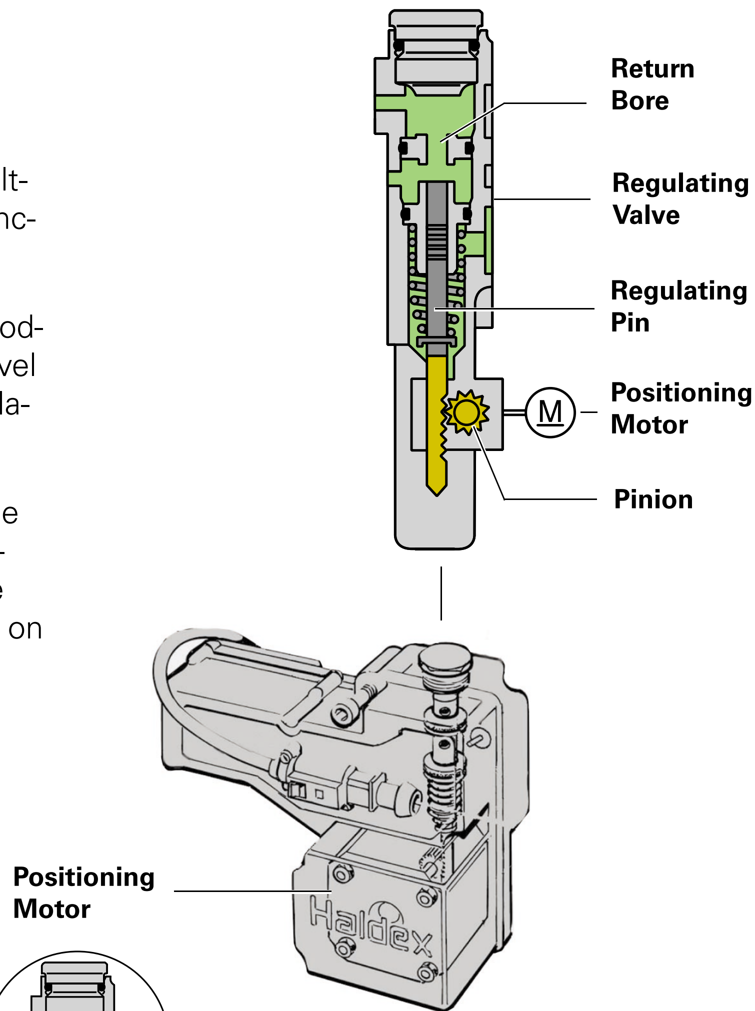
The positioning motor is integrated in the Haldex control module housing.

Design and function

The positioning motor is supplied with voltage by the Haldex control module and functions as a stepping motor.

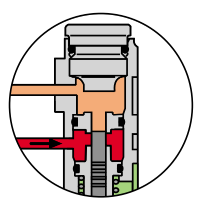
At the command of the Haldex control module, the positioning motor changes the level of the regulating pin in the pressure regulator via a small pinion gear.

The level of the regulating pin changes the cross section of a return bore in the pressure regulator. This controls the pressure acting on the working piston, and in turn, on the clutch plates.



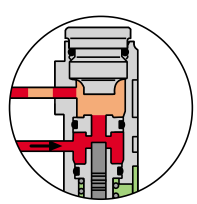
Regulator Closed:

Maximum pressure on clutch plates.



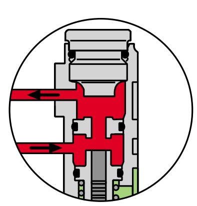
Regulator Partially Open:

Reduced pressure on clutch plates.



Regulator Fully Open:

No pressure on clutch plates.

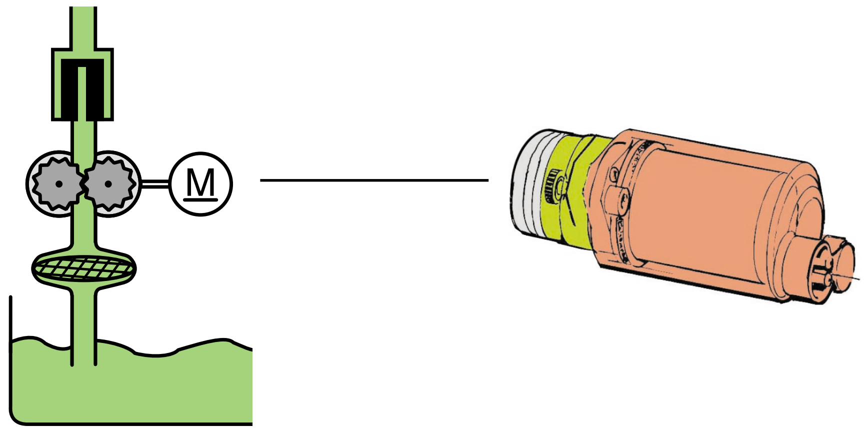


Haldex Clutch Pump V181

The pump for the Haldex coupling is attached to the Haldex coupling housing.

Design

After the engine has been started, the pump for the Haldex coupling is supplied with voltage by the Haldex control module as soon as the engine speed exceeds 400 rpm.



Haldex Clutch Pump

Function

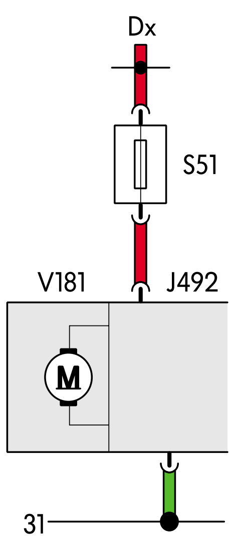
The pump for the Haldex clutch conveys oil to the lifting piston and brings the lifting piston into contact with the lifting plate via roller bearings.

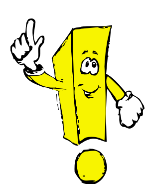
At the same time, oil reaches the working piston. This eliminates any play from the clutch plate set and ensures quick clutch response.

Effects of signal failure

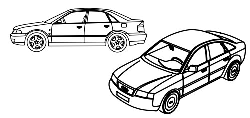
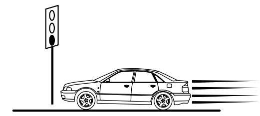
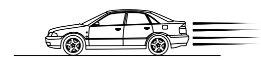
No all-wheel drive.

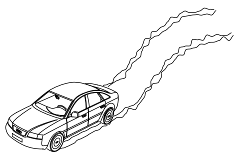
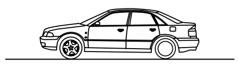
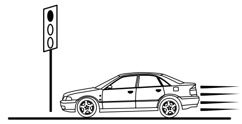
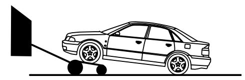
Electrical circuit





The Haldex clutch pump is directly supplied with voltage by the Haldex control module.

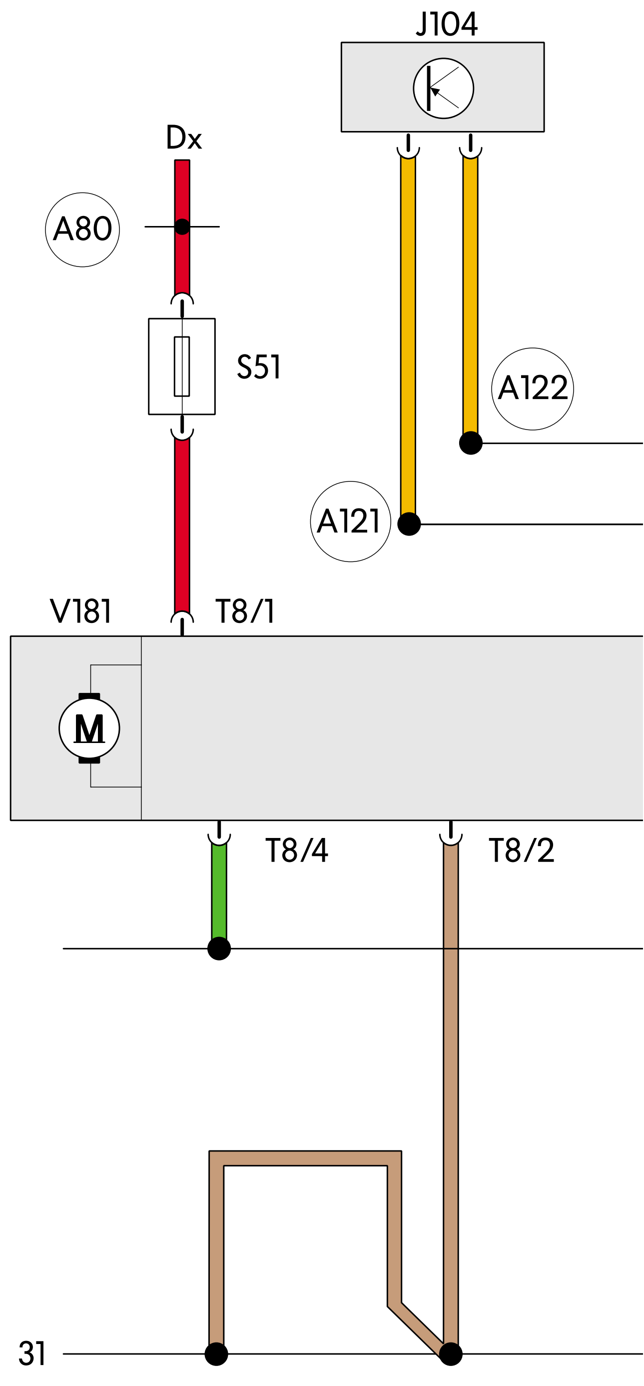
	 Parking	 Acceleration	 High-speed Driving
Difference in speed between front and rear axles	Low	High	Low
Torque required at the rear axle	Low	High	Low
Condition of multi-plate clutch	Low contact pressure	High contact pressure, up to maximum. EDL control system can increase contact pressure.	Closed, as required
Input Signals	• Engine torque • Engine speed • Accelerator pedal position • Four wheel sensors	• Engine torque • Engine speed • Accelerator pedal position • Four wheel sensors	• Engine torque • Engine speed • Accelerator pedal position • Four wheel sensors

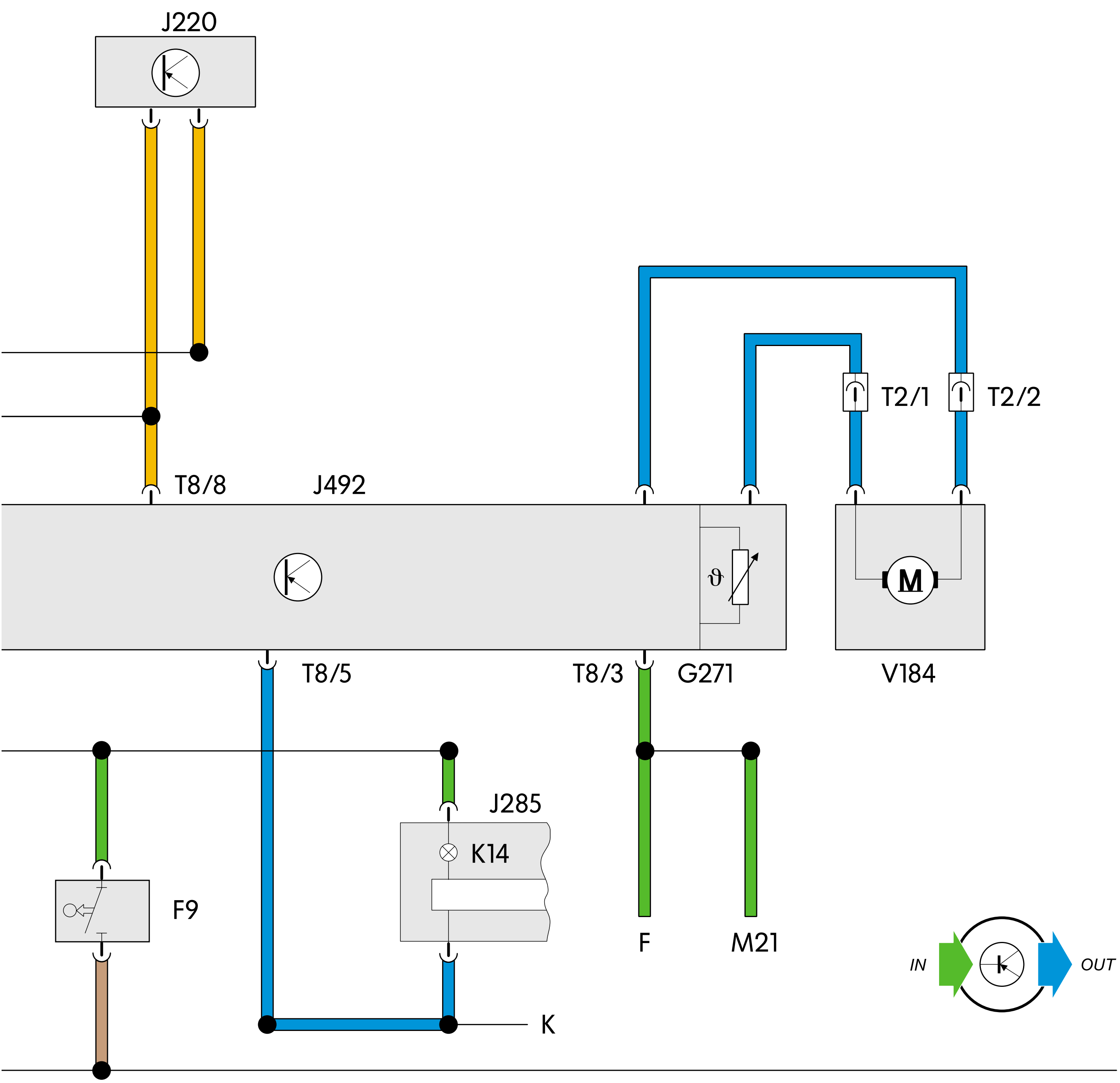
 **Slippery Surfaces**	 **Emergency wheel installed**	 **Braking**	 **Towing**
Fluctuates between low and high	Normal to high	Normal to high	High
Fluctuates between low and high	Low	0	0
Closed, up to maxi- mum	Open or slightly closed	Open	Open, electrical pre-pressure pump is off when ignition is off
• Engine torque • Engine speed • Accelerator pedal position • Four wheel sensors • CAN-bus communication	• Four wheel sensors • via ABS control unit	• Four wheel sensors • via ABS control unit • Brake light switch	• Engine speed less than 400 rpm

- Input signal
- Output signal
- Positive
- CAN
- Ground

Components

D	Ignition switch
F	Brake light switch
F9	Hand brake warning switch
G271	Hydraulic temperature sensor
J220	Motronic engine control module
J104	ABS control module with EDL/TCS/ESP in the engine compartment at the left
J285	Control module with display unit in the dash panel insert
J492	Control module for four-wheel drive (located near the rear axle differential)
K	Connection (K-wire (diagnosis))
K14	Handbrake warning lamp
M21	Bulb for left rear brake
S51	Fuse
V181	Haldex clutch pump
V184	Positioning motor for oil pressure
A80	Connection -1- (x) in dash panel wiring harness
A121	Connection (Hi bus)
A122	Connection (Low bus)




J220
T8/8
J492
T2/1
T2/2
T8/5
T8/3
G271
V184
M
J285
K14
F9
F
M21
K
IN
OUT

Self-diagnosis

The self-diagnosis electrically monitors:

- the signals generated by the sensors
- activation of the positioning motors
- the control unit by carrying out a self-test

If the control unit detects a fault, it calculates a substitute value from other signals and makes an emergency running program available.

In the data transfer facility, the following functions can be read out under the address word 22 "4-wheel-drive electronics" with the VAS 5051 testing and information system:

02 Check DTC Memory

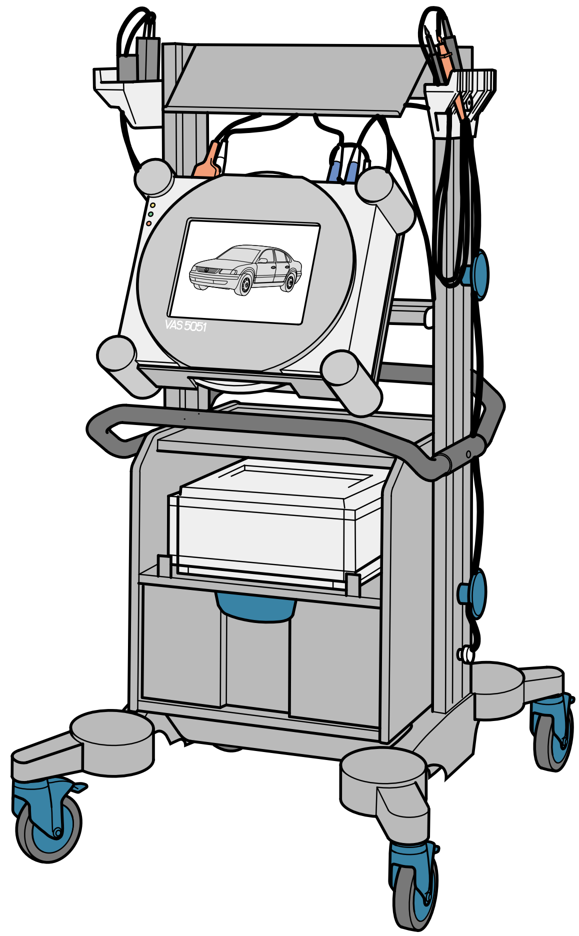
03 Output Diagnostic Test Mode (DTM)

05 Erase DTC Memory

06 End Output

08 Read Measuring Value Block

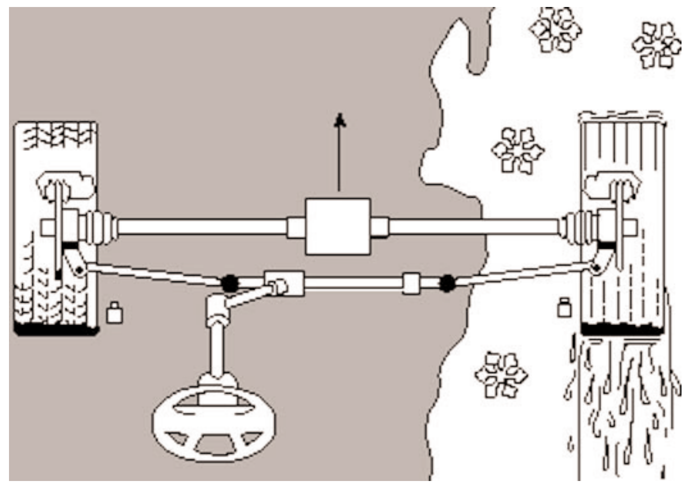
For more detailed information, please refer to AESIS.



VAS 5051 Scan Tool

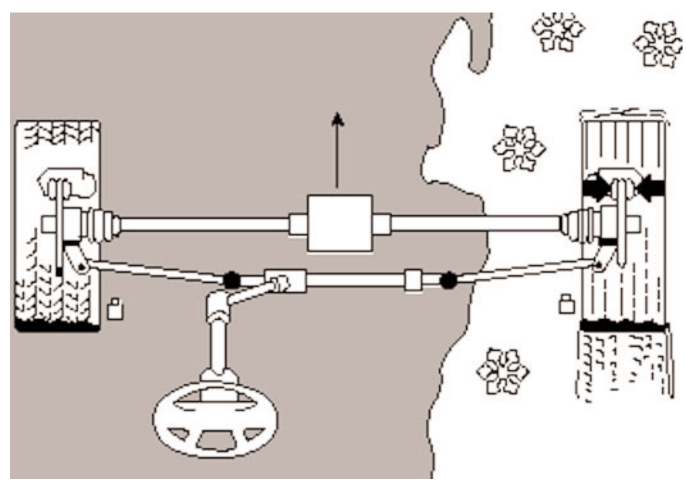
The Haldex coupling and the Torsen differential transfer power to both the front and rear differentials.

Since the current Audi front and rear differentials are not locking differentials, Electronic Differential Lock (EDL) is used to control wheel slip.



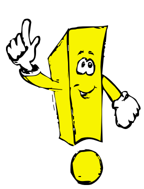
Without EDL

When one drive wheel on each side is on a slippery surface under acceleration, the power is transmitted through the front and rear differentials to the path of least resistance, to the tire with reduced traction. The center differential can only make sure both axles are getting the correct amount of power.



With EDL

With the power going to the path of least resistance, the two wheels on ice will slip. EDL is used to redistribute torque in this situation.



This is the same system that is used on front-wheel drive cars.

Electronic Differential Lock

EDL uses the same sensors and components that the anti-lock brake system (ABS) uses to control traction.

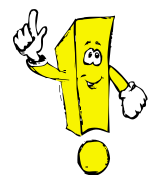
The wheel speed sensors send information to the ABS/EDL control module J104. When there is a difference in wheel speeds, the EDL function will apply the brakes to the wheel that is spinning to control slip. When brakes are applied to the wheel that is spinning, power will automatically be sent through the differential to the wheel that has traction.

The brake light switch F informs the ABS/EDL control module when the brakes are being applied.

EDL and the center differential work together to maintain the most traction in any situation.

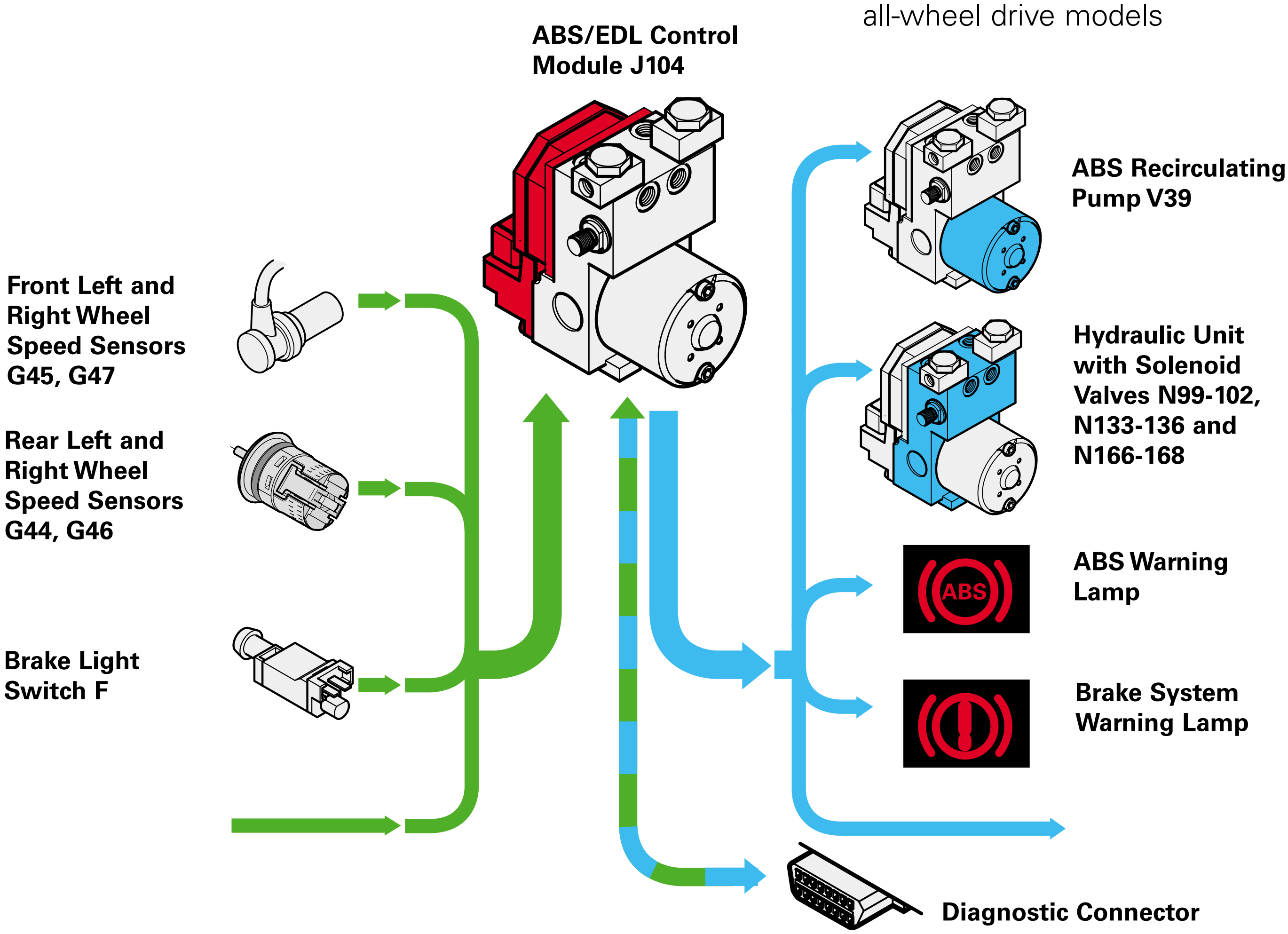
For example - if the vehicle is on a large patch of ice and only one wheel has traction, EDL will pump the brakes of the wheels that are spinning.

The center differential will redirect power to the axle that is getting the most traction, enabling the vehicle to move.



EDL does not operate:

- When the brakes are applied
- Over 25 mph (40 km/h) on FWD models
- Over 50 mph (80 km/h) on all-wheel drive models



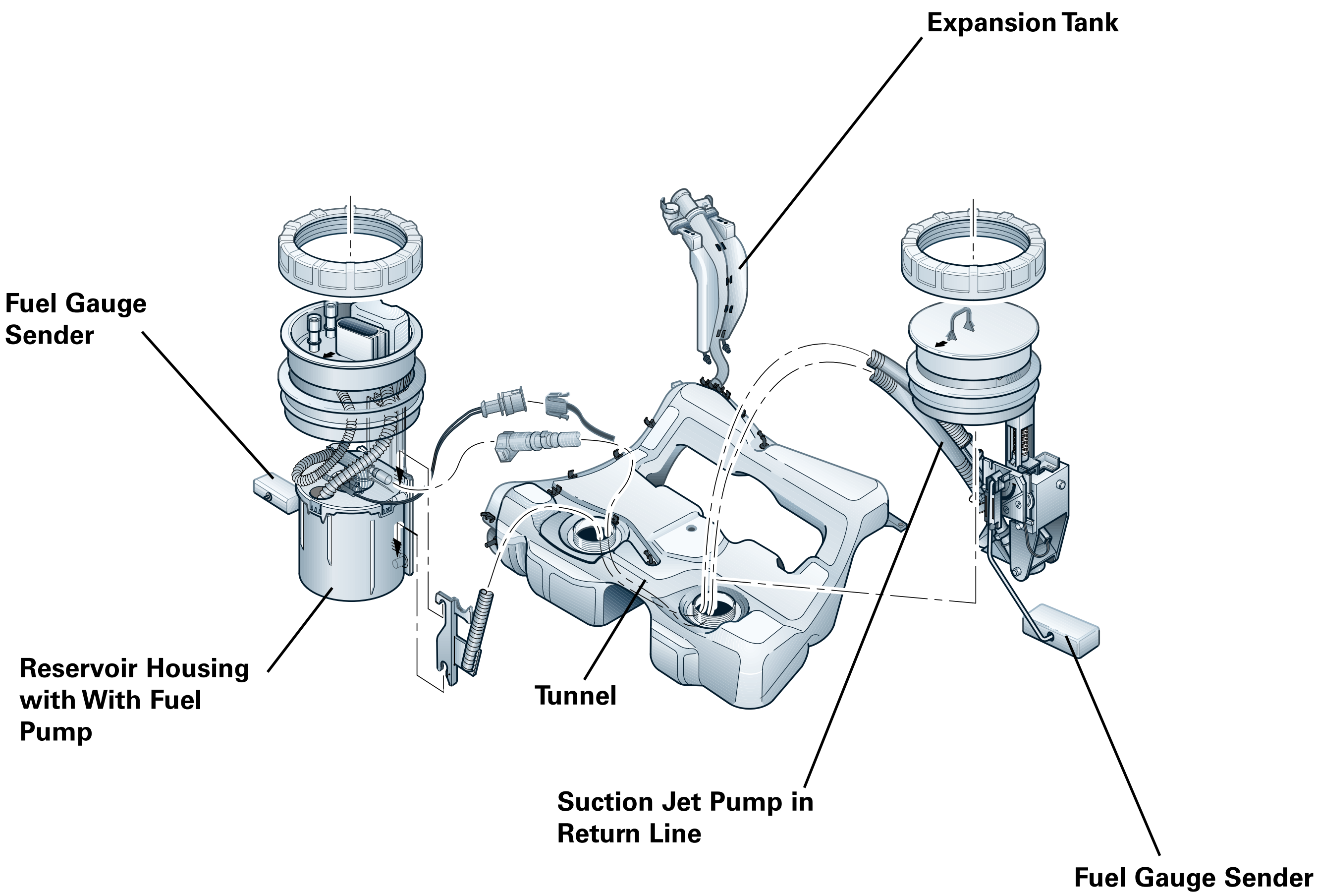
The fuel tank for quattro vehicles is much different than the fuel tank for front-wheel drive vehicles. The center differential and rear axle take up much of the space where the front-wheel drive vehicle's tank occupied. As a result, the tank has a different shape and includes different components and systems to assure correct operation.

A tunnel provides the space required for the prop shaft. The result of this is a "divided tank" construction.

A suction jet pump driven by the two-stage fuel pump via the fuel return line pumps fuel from the left half of the fuel tank into the reservoir housing of the fuel pump.

The fuel tank has either two or three sending units, depending on the model.

The individual resistances of the senders are added together to get a total resistance. A microprocessor in the instrument cluster processes this data.



1. On early quattro systems, _________.

1. The front differential did not have the ability to lock
2. The center and rear differentials could be locked manually
3. The front and center differentials could be locked manually
4. Both A and B

2. What model(s) use the Haldex coupling?

1. TT
2. A8
3. A6
4. A4

3. The Haldex Coupling has an oil filter that should be changed with the fluid at which of the following intervals?

1. 5,000 miles (8000 km)
2. 10,000 miles (16,000 km)
3. 15,000 miles (24,000 km)
4. 20,000 miles (32,000 km)

4. The Haldex control module utilizes which of the following signals over the CAN bus?

1. Wheel Speed Sensor
2. Brake Light Switch
3. Handbrake Switch
4. All of the above

5. The Haldex control module is located __________.

1. under the rear seat
2. on the housing of the Haldex coupling
3. next to the ECM
4. on the ABS hydraulic unit

6. The Longitudinal Acceleration Sensor is used for the quattro system on which of the following?

1. All vehicles with a Torsen differential
2. All vehicles with a Haldex coupling
3. On all Audi models
4. On Audi V8 models

7. The pump for the Haldex Coupling is supplied voltage by the Haldex control module as soon as __________.

1. fluid temperature exceeds 100 degrees F
2. engine speed exceeds 400 rpm
3. the vehicle is started
4. the Haldex Control Module receives a Wheel Speed Sensor input

8. All current Audi models equipped with the Torsen differential and Haldex Coupling use EDL to control wheel slip. At what point will the EDL turn off?

1. When the brakes are applied.
2. Over 25 mph (40 km/h) on FWD models.
3. Over 50 mph (80 km/h) on all-wheel drive models.
4. All of the above.

9. The Torsen Torque Bias Ratio (TBR) is about:

1. 1:1
2. 1:2
3. 3:1
4. 2:1

10. Technician A says that if the Hand Brake Switch F9 fails on a TT quattro, the vehicle will not have all wheel drive. Technician B agrees, but adds that ABS may not function correctly. Who is correct?

1. Technician A only
2. Technician B only
3. Both technician A and B
4. Neither technician A or B

Audi of America, Inc.
3800 Hamlin Road
Auburn Hills, MI 48326
Printed in U.S.A.
June 2001